UNITED STATES
DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

H. H. Bennett, Chief
W. C. Lowdermilk, Associate Chief and Acting
Head of Division of Research

DETAILED WORKING PLAN
for
WATERSHED STUDIES IN THE NORTH APPALACHIAN REGION

(Relating to Water Conservation, Flood Control, and Run-off as Influenced by Land Use and Methods of Erosion Control)

by

C. E. Ramser
Head of Section of Watershed and Hydrologic Studies
and
D. B. Krimgold
Assistant to Head of Section

WHS #1
November 1935

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

H. H. Bennett, Chief
W. C. Lowdermilk, Associate Chief and Acting
Head of Division of Research

DETAILED WORKING PLAN
for
WATERSHED STUDIES IN THE NORTH APPALACHIAN REGION
relating to
WATER CONSERVATION, FLOOD CONTROL, AND RUN-OFF
AS INFLUENCED BY LAND USE AND METHODS OF EROSION CONTROL

by

C. E. Ramser
In Charge, Section of Watershed and Hydrologic Studies
and
D. B. Krimgold
Associate Hydraulic Engineer

COPY

UNITED STATES DEPARTMENT OF AGRICULTURE
Office of Experiment Stations
Washington, D. C.

November 4, 1935

MEMORANDUM FOR THE SECRETARY

Dear Mr. Secretary:

The Research Committee for cooperation between the Soil Conservation Service and other agencies has examined the attached proposed research project, Detailed Working Plan for Watershed Studies in the North Appalachian Region, submitted by the Soil Conservation Service.

In accordance with memorandum No. 675, of August 9, from the Acting Secretary, the proposed project was reviewed and copies forwarded to the Chief of the Weather Bureau, the Chief of the Bureau of Chemistry and Soils, the Forester, and the Chief of the Bureau of Agricultural Engineering.

By memorandum of October 22, the Chief of the Weather Bureau commends the project, advising that the resulting data should be of genuine value to the Weather Bureau itself in connection with the forecasting of floods and for studies as to effective precipitation having an important bearing on meteorology. He suggests the importance of close relationship of the Weather Bureau to the project, and, perhaps, assumption by the Weather Bureau of responsibility for certain phases of the work.

By memorandum of October 24, the Chief of the Bureau of Chemistry and Soils raises the question of relationships of the Soil Conservation Service and the Bureau of Chemistry and Soils in the soil survey work to be undertaken in connection with this project. It is the judgment of the Committee that, in addition to proper relationships as regards the soil surveys, there is an opportunity in connection with this project for advantageous relationships between the Soil Conservation Service and the Bureau of Chemistry and Soils in other phases of soils research.

By memorandum of October 26, the Forester commends the proposed project and suggests the opportunity for helpful relationships in forestry phases of the proposed work. As a means of bringing about the desired cooperation he suggests that the director of the regional Forest Experiment Station and the regional director of the Soil Conservation Service get together and study the situation in the field.

By memorandum of October 21, the Chief of the Bureau of Agricultural Engineering comments upon the apparent careful consideration given to the planning of the proposed project and advises that there is no apparent need of cooperation with that Bureau inasmuch as the Bureau has no similar work underway.

November 4, 1935

MEMORANDUM FOR THE SECRETARY (Concluded)

The Committee commends the care with which this proposed project has been outlined. The investigation appears to be one of real importance and properly within the field of Soil Conservation Service as to initiative and leadership. Your approval of the project is recommended with the following suggestions to the Soil Conservation Service and the bureaus named:

(1) Weather Bureau - Since the proposed investigation will involve a considerable amount of meteorological work and has possibilities of contributing data of genuine value to the Weather Bureau, the meteorological observations should be worked out so there is agreement between the Soil Conservation Service and the Weather Bureau. It is suggested that the Soil Conservation Service take the initiative in consulting the Weather Bureau and in working out a supplemental cooperative memorandum of understanding to be submitted to the Committee and the Secretary as a part of the administrative record in this case.

(2) Bureau of Chemistry and Soils - As in the case of the Weather Bureau, it is suggested that the Soil Conservation Service take the initiative for conferences and the working out of a supplemental cooperative memorandum of understanding with the Bureau of Chemistry and Soils covering relationships and respective responsibility of the bureaus in connection with soil surveys and soils research phases of the project. This memorandum should be submitted through the Committee to the Secretary as a part of the administrative action in this case.

(3) Forest Service - The memorandum and suggestions from the Forester indicate an excellent spirit of cooperation. His suggestions should be followed and perhaps the plans for cooperation agreed upon should be reported back to the Secretary, through the Committee, in the form of a supplemental memorandum.

Copies of comments from the bureaus are attached.

Concurred in:

James T. Jardine
M. S. Eisenhower
W. C. Lowdermilk

(Sgnd.) H. A. Wallace
Secretary

November 5, 1935
Date

By (Sgnd.) James T. Jardine

Enclosures

Washington, D. C.
October 16, 1935

MEMORANDUM to Interbureau Research Committee,
Dr. J. T. Jardine, Chairman.

Dear Dr. Jardine:

In accordance with the provisions of Section II of the "Report of the Secretary's Committee on Soil Conservation", I am submitting for consideration and approval by your Committee the attached "Detailed Working Plan for Watershed Studies in the North Appalachian Region". Similar working plans will be prepared for the Watershed Studies to be carried on in the remaining nine regions as called for in the "Provisional Plan", (Appendix I).

Sincerely yours,

W C Lowdermilk

W. C. Lowdermilk,
Acting Chief.

TABLE OF CONTENTS

DETAILED WORKING PLAN

INTRODUCTION

The "DETAILED WORKING PLAN FOR WATERSHED STUDIES IN THE NORTH APPALACHIAN REGION", together with Appendices I, II, III, and IV, represents a sample of the working plans to be prepared for each of the watershed studies to be made in the ten typical agricultural regions of the United States. The figures attached to the "DETAILED WORKING PLAN" represent the general types of structures, apparatus, and installations to be employed in the studies. Special designs of the above will be made and new types will be developed to fit the conditions and problems encountered in the various regions.

As a result of an exhaustive study, described in Appendix II, "SELECTION OF AN EXPERIMENTAL WATERSHED FOR THE NORTH APPALACHIAN REGION", the watershed known as Q, located in Coshocton County, Ohio, within the boundaries of the Muskingum Watershed Conservancy District, was selected.

In accordance with the provisions of the "Report of the Secretary's Committee on Soil Conservation" the plans for the proposed watershed studies in the North Appalachian Region were approved by the OHIO STATE ADVISORY COUNCIL ON SOIL CONSERVATION. See attached letter of approval addressed to Mr. H. H. Bennett, Chief, Soil Conservation Service, page 2.

The Board of Directors of the Muskingum Watershed Conservancy District is vitally interested in the results of the watershed studies, and expressed their willingness to cooperate in securing the control of the necessary land and offered continual assistance throughout the life of the studies. Copies of correspondence from the Muskingum Watershed Conservancy District are given on pages 3, 4, and 5.

COPY

Zanesville, Ohio,
August 28, 1935.

Mr. H. H. Bennett,
Director,
Soil Conservation Service,
Washington, D. C.

Dear Mr. Bennett:

The State Advisory Council on Soil Conservation has investigated the proposed watershed studies being developed by the Research Division. The committee is glad to approve the tentative plans developed and feels that the prosecution of such an experiment will furnish important and essential information of value, not only to the farmers of Ohio, but also to the Muskingum Watershed Conservancy District in the operation of its flood control plan. We especially wish to commend the painstaking and careful manner in which the selection of the final watersheds was made by Mr. Krimgold.

The committee requests the opportunity of analyzing and inspecting the final plans for the experimental watershed studies when they are completed. In this way, it will be possible for the ideas and suggestions of the research workers in Ohio to be presented to the Research Division of the Soil Conservation Service.

Respectfully submitted,

(signed) J. S. Cutler
J. S. Cutler, Regional Director,
Soil Conservation Service

(signed) H. C. Ramsower, Director
H. C. Ramsower, Director of Extensions,
Ohio State University

(signed) C. G. Williams
C. G. Williams, Director,
Ohio Agricultural Experiment Station

COPY

August 17, 1935.

Dr. Hugh H. Bennett, Chief,
Soil Conservation Service,
Washington, D. C.

Dear Dr. Bennett:

Mr. D. B. Krimgold, Assistant to Mr. C. E. Ramser of your Division of Watershed and Engineering Studies, is now in our District making certain investigations with the idea in mind of selecting an area for Watershed study.

We wish to advise you of our deep interest in this development, and assure you of our desire to co-operate in every possible way in its completion. The services of our entire organization, including our Legal, Land Appraisal, Land Purchase, and Engineering departments, are available for your use. We have already arranged to send survey and plane-table parties into the field to make any detailed investigations which may be desired. You may also be assured of our continued assistance and cooperation throughout the life of this project.

If it happens that the site selected is adjacent to one of our reservoirs where we have land purchase authority, we would be willing to lend financial assistance in the acquiring of the necessary lands. In any instance you may be assured of our assistance in working out any financial problems which may develop.

In conclusion, we feel that this project is of greatest importance, and that the information to be secured is absolutely essential to the operation of flood control districts such as ours.

With kindest regards, we are

Yours very truly,

Board of Directors,
Muskingum Watershed Conservancy District

By______________________________
Bryce C. Browning
Secretary-Treasurer

BCB/B

Enc.

C O P Y

MUSKINGUM WATERSHED CONSERVANCY DISTRICT

New Philadelphia, Ohio

September 24, 1935

Dr. W. C. Lowdermilk,
Assistant Chief,
Soil Conservation Service,
Department of Agriculture,
Washington, D. C.

Dear Dr. Lowdermilk:

I wish to apologize for the delay in answering your very interesting letter concerning the proposed experimental watershed study.

Your letter has been referred to our various department heads and to the Board of Directors, and was greatly appreciated by all.

The Board of Directors passed a resolution concerning the matter of cooperation on the part of the District, which was addressed to Mr. Cutler as the Regional Director, and which will probably reach you in the near future.

I have already contacted community leaders in each of the districts you are considering for the project, and find them greatly interested in the project. We feel quite certain we will be able to work out the land situation in a manner pleasing to you.

Attached is a copy of an inter-office memorandum from Mr. C. C. Chambers, our Chief Engineer, concerning this project, which will be of interest to you.

Yours very truly,

(signed) Bryce C. Browning
Bryce C. Browning
Secretary-Treasurer.

BCB/LH
Encl.

C O P Y

MUSKINGUM WATERSHED CONSERVANCY DISTRICT

Inter-Office Memo

September 21, 1935.

To Bryce C. Browning

From C. C. Chambers

I have been very much interested in reading the letter from Mr. Lowdermilk dated September 10 and directed to you in regard to establishing experimental watersheds in the Muskingum Conservancy District area for carrying on experimental studies to determine the effects of proper land use and various erosion control practices upon run-off, conservation of water, and the control of floods.

I personally consider this a very worthwhile piece of work that the Government can well undertake and that the results should be of great value to the District and also to other organizations interested in flood control, water conservation and the control of soil erosion in the part of the country where conditions are similar to this area.

I consider that it is highly desirable for the District to give any practicable cooperation it can toward the success of this undertaking. If properly conducted, the results should be particularly interesting to the engineering department of the District and to the engineering profession at large. We will not only like to offer our assistance but will be interested in keeping in close touch with the details of the developments so that these experimental studies can be coordinated with the hydraulic studies of the District, which I think would be to the mutual advantage of both parties.

(Signed) C. C. Chambers

CCC:FW

DETAILED WORKING PLAN
FOR
WATERSHED STUDIES IN THE NORTH APPALACHIAN REGION

1. NORTH APPALACHIAN PROJECT

Watershed studies relating to water conservation, flood control, and run-off as influenced by land use and methods of erosion control are to be carried on in the North Appalachian Region of the United States.

The experimental watershed study in the North Appalachian Region is one of ten to be inaugurated by the Soil Conservation Service in the various broad type areas in the United States. A complete general description of the major project, of which this is a subproject, is given in the "PROVISIONAL WORKING PLAN FOR WATERSHED STUDIES Relating to WATER CONSERVATION, FLOOD CONTROL, AND RUN-OFF AS INFLUENCED BY LAND USE AND METHODS OF EROSION CONTROL to be carried on in TYPICAL AGRICULTURAL REGIONS OF THE UNITED STATES".

II. LOCATION

In accordance with the provisions of the above mentioned Provisional Plan a thorough study of maps and materials pertaining to the North Appalachian Region was made in the Washington Office by D. B. Krimgold under the direction of C. E. Ramser. These studies resulted in examining a large number of possible watersheds located in Eastern Ohio within the Muskingum River Watershed. The Washington Office studies, in which 10 men were employed for a period of 2 weeks, were followed by an exhaustive field reconnaissance survey conducted by D. B. Krimgold in Eastern Ohio. The field reconnaissance survey, in which several members of the S.C.S. field staff were employed for more than a month, resulted in the final selection of a watershed

designated as Q in Figure #1. This watershed is located 8.5 miles north of Coshocton, Ohio, and comprises the watershed of Little Mill Creek, a tributary of Mill Creek which drains into the Walhonding River.

In anticipation of difficulties which may arise in securing the control of the land on Watershed Q, five additional watersheds, designated in Figure #1 as Q', L and L', and W and W", were thoroughly investigated and were found feasible.

The above mentioned watersheds were carefully investigated in the field by Mr. C. E. Ramser. On September 2, 1935, the areas Q and W' were inspected by Mr. H. H. Bennett and Dr. W. C. Lowdermilk. The method developed for the selection of the location and the detailed procedure employed are fully described in Appendix II, entitled "Selection of an Experimental Watershed for the North Appalachian Region."

II. OBJECT

The objectives of the watershed studies in the North Appalachian Region are:

(A). To determine the effect of land use and erosion control practices upon the conservation of water for crops and water supply and upon the control of floods under conditions prevailing in the North Appalachian Region of the United States.

(B). To determine the effect under (A) for small and large areas and to trace variations in this effect from the smallest ~~plot and lysimeters~~ through a series of intermediate watersheds to the largest watershed on the project.

(C). To determine the rates and amounts of run-off for precipitation of different amounts and intensities for watersheds typical of the North Appalachian Region of different configuration, size, shape, topography, cover, underground conditions, land use, and erosion control practices. To furnish data needed for use in the design of erosion control structures and in the design and operation of the Muskingum Watershed Conservancy District and other flood control projects lying within the North Appalachian Region.

IV. REASONS FOR STUDY

The reasons for study as given in the Provisional Working Plan, Appendix I, Page 4, apply in general to this project. There are, however, some considerations which apply specifically to the North Appalachian Region as a whole and to the Muskingum Watershed Conservancy District and similar areas within the region in particular. Following is a brief discussion of these considerations.

(A). Water Conservation

The importance of water conservation even under the comparatively humid conditions of the North Appalachian Region has been clearly shown during the recent dry years. Crop failures resulted from deficient soil moisture. Numerous urban water supplies derived from wells were diminished to a point of danger and in practically all cases the pumping lifts were greatly increased. The case of the City of Canton, where the ground water level has declined from

8 to 14 feet, to 30 to 100 feet below the surface, is typical for the Region; (see Article by O. E. Meinzer, Engineering News-Record, May 2, 1935, Page 622). The decrease in surface flow of the numerous streams resulted in low stages in the Ohio River and its tributaries, which aggravated the pollution problem and impaired navigation.

Experiments on small plots indicate that land use and erosion control practices employed on the agricultural land comprising the watersheds of the region have a marked influence on the total and rates of surface run-off, and on the amount of water available for soil moisture. Studies such as are proposed in this project are needed in order to accurately determine the effect of proper land use and of erosion control practices on water conservation under actual conditions of natural watersheds.

(B). Flood Control

Recent floods in Eastern Ohio, West Virginia, and Western Pennsylvania, all lying within the North Appalachian Region, resulted in enormous losses to both the urban and rural population of the region. The losses due to the August flood of 1935 in the Muskingum Valley alone amounted to $5,000,000.

The Muskingum Watershed Conservancy District com-

prising 8,100 square miles in Southeastern Ohio is at present carrying out a $53,000,000 program of water conservation and flood control under a PWA allotment. This District has recently submitted an extended program which includes several erosion control projects on the contributing watersheds for the purpose of water conservation and flood control.

Surveys and studies are under way on the Scioto River Watershed for the purpose of inaugurating a program similar to that of the Muskingum Watershed Conservancy District. The damages from the floods of the Hocking River in Ohio and of various streams in West Virginia and Western Pennsylvania will eventually lead to similar programs involving expenditures of many millions of dollars.

In view of the above, it is important that the studies proposed in this plan be started as soon as possible. The proposed studies will yield satisfactory information on the effect of erosion control measures on flood flows, water conservation, and the rate of silting of reservoirs, which will be of value in the preparation of plans for flood control districts in the North Appalachian Region. That such information is urgently needed is evident from a letter from the Board of Directors of the Muskingum Conservancy District

dated August 17, 1935, to Mr. H. H. Bennett, Chief of the Soil Conservation Service. A copy of this letter is attached to this plan. See Introduction, Page 1.

(C). Rates and Amounts of Run-off from Agricultural Areas

In addition to the statement given under the same heading in the Provisional Working Plan, it may be said that the results obtained in the proposed studies will yield information needed by the Muskingum Watershed Conservancy District and similar districts in the design of detention and storage reservoirs, and in the later development of the operation schedules relating to regulation of reservoir storage.

V. THE PROBLEM

(A). Statement

The problem consists of a detailed and comprehensive study of the effects of agricultural land use on the action of water from the time it reaches the ground surface as precipitation until it leaves the watershed as surface or underground flow, which will include studies of precipitation, percolation, evaporation, transpiration, surface and underground storage, and rate of movement over the ground surface and through stream channels.

(B). Factors

A more detailed outline of the factors to be considered and analyzed in the ultimate solution of the problem in their relation to run-off, water conservation,

and flood control are given below:

(1). Physical characteristics of watersheds

- (a). Soil and subsoil
  1. Texture
  2. Structure
  3. Composition
  4. Degree of saturation
- (b). Topography
  1. Degree and length of slopes
  2. Uniformity and regularity of ground surface across and along slopes.
- (c). Physiography
  1. Arrangement of drainage systems
- (d). Cover
  1. Wood lots
  2. Pasture
  3. Cultivated and other crops
- (e). Storage
  1. Surface
  2. Underground
- (f). Geological formation
- (g). Artificial factors
  1. Tillage practices
  2. Erosion control practices

(2). Precipitation

- (a). Amount

(b). Intensity

(c). Duration

(d). Distribution

1. Over watershed

2. Seasonal

(3). Water disposal

(a). Evaporation

(b). Percolation

1. Ground water reaching streams

2. Deep seepage; that is, water not appearing again in drainage channels of watershed.

(c). Interception and transpiration

(d). Surface run-off

In addition to measurements and studies of the foregoing factors, continuous records will be kept and studies made of: the direction and velocity of wind, humidity, air and soil temperatures, and atmospheric pressure.

VI. FORMER WORK

A brief general description of various similar studies carried on in the past and now in progress in the United States and in Europe is given on Page 6 of the Provisional Plan (See Appendix I). It should be noted, however, that no studies such as are proposed in this plan have been made in the North Appalachian Region.

VII. EXPERIMENTAL PROCEDURE AS PLANNED

The general plan of study consists of first, the evaluation of all important factors by carefully conducted experimental studies, and second, tracing the operation of such factors from small to large watersheds.

(A). Lysimeters and small plots

The isolation and measurement of the effect of each particular factor influencing surface run-off and soil erosion is accomplished by:

(1). Tanks or lysimeters designed to measure, for natural and artificial rainfall of different intensities, duration, and amounts:

(a). The amount and rate of percolation into the soil under different soil surface conditions.

(b). Transpiration and evaporation loss from mass of soil 3 or 4 feet deep.

(c). Influences of vegetation and organic matter on surface run-off and soil erosion.

(2). Surface run-off plots of different sizes (1/100 to 1/4 acre) and on different slopes in duplicate designed to measure the:

(a). Influence of various factors such as vegetation, tillage practices, crop rotations, and organic matter upon surface run-off and soil erosion under natural rainfall conditions.

(b). Influence of size of plot, degree of slope and length of slope upon surface run-off and soil erosion.

(c). Effect of different rainfall intensities on rate of surface run-off and soil erosion.

Twenty to thirty plots ranging in size from 1/100 to 1/4 acre will be installed in the immediate vicinity of headquarters. The total amounts and rates of soil and water run-off from the plots will be measured.

(B). Small Watersheds

Small watersheds of 5 to 15 acres will be used for experiments on the effect of erosion control practices upon the rates and amounts of run-off and soil erosion for rainfall of different amounts and intensities. Erosion control practices that will be used will depend upon their adaptability to the particular region. Some of these practices will be pasture, forest, cover and green manure crops, crop rotations, various tillage methods, strip cropping and terracing.

Where suitable watersheds are available, experiments will be conducted to determine the effect of shape, slope and arrangement of drainage channels upon run-off and erosion. For instance, it is particularly desired to know the difference in run-off and erosion

between concave shaped areas where the water concentrates as the streams or rivulets converge in proceeding down the slopes, and convex shaped areas where the streams diverge in traveling down the slopes. Measurements will be made to determine the effect of the various conditions and practices upon the time of concentration of the watersheds.

The above general statement with regard to small watersheds was taken from the Provisional Plan. See Appendix I, Page I-8. The following schedule of operations is to be used in the North Appalachian Region:

(C). Intermediate Watersheds

The following statement is taken from the Provisional Plan. On intermediate watersheds with areas ranging from 30 to 4,000 acres the effect of size of watershed upon rate and amount of run-off and erosion for rainfall of different amounts, durations, and intensities will be determined. Run-off coefficients giving both the ratio of maximum rate of run-off to maximum rate of rainfall and the ratio of the total run-off to the total rainfall will be determined. Also measurements will be made to determine the time of concentration for each watershed for different seasons of the year, different conditions of channels and for different rainfall intensities. Lag in the movement

of run-off due to storage or other factors will also be studied.

The selected watershed Q (See Figure #2) consists of 19 separate intermediate watersheds varying in size from 42 to 532 acres and designated by #1 to #18 and I. Cooperative agreements will be signed with the owners and operators of the land lying within Q which will provide that the best known practices of erosion control and of land use will be practiced for a period of 20 years. A copy of the proposed agreement is given in Appendix III. The silt and water run-off from these watersheds, as well as from 5 to 7 watersheds lying outside and immediately adjacent to Watershed Q, (#19 to #25), on which prevailing practices will be allowed to continue, will be measured. The results obtained from the small and intermediate watersheds together with those obtained from the gaging stations along the main stream of watershed Q designated as I to VI in Figure #2 will be used in constructing curves for the North Appalachian Region giving rates of run-off from watersheds of various characteristics and ranging in size from 3 acres to 5,000 acres. These curves will be based entirely on results of actual measurements and will supersede the curves developed by Mr. C. E. Ramser, which are based on a limited number of actual

measurements for watersheds up to 100 acres in area, and are now extensively used in the design of erosion control and other structures. A set of these curves together with instructions for their use, taken from "BRIEF INSTRUCTIONS ON METHODS OF GULLY CONTROL" by C. E. Ramser, are given in Appendix IV.

Periodic surveys of the vegetative cover and land use will be made on all intermediate watersheds. The survey data and the results of run-off measurements from these watersheds will also serve to determine the effect of erosion control measures on water and soil conservation and on flood flows from watersheds ranging in size from 40 to 5,000 acres.

(D). Major or Master Watersheds

The watershed Q, Figure #2, having an area of 4883 acres has been selected as the Master Watershed on this Project. The measurement of the total flow from the Master Watershed will afford a check on the sum total of the flow from all the smaller tributary watershed units within the Master Watershed. Studies on these master watersheds will furnish information on run-off, water conservation and flood control for watersheds of the largest size for comparison with similar data obtained from the several smaller watersheds of different sizes.

The watershed designated as Q' in Figure #2 will be used as a check area on which rates and amounts and silt movement will be measured. Prevailing practices of cultivation and land use will be allowed to continue on Q'.

Complete initial surveys and periodic surveys of vegetative cover and land use will be made on both Q and Q'. To better serve the purposes of the Muskingum Watershed Conservancy District and of other similar districts in the region, it is proposed to install gaging stations and a small number of recording and standard rain gages and to make the necessary surveys on an additional number of watersheds lying within the boundary of the District. The Watersheds M and 8 and W" and V shown in Figure #1 will be used for the purpose. It is expected that the Muskingum Watershed Conservancy District will participate in the initial cost and maintenance of the structures and will make the necessary surveys of the four watersheds mentioned above. It is also proposed to make arrangements with the U. S. Geological Survey by which silt samples will be collected at some of the gaging stations maintained by the U. S. G. S. on larger streams in the vicinity of the experimental watersheds.

SCHEDULE OF OPERATIONS ON SMALL WATERSHEDS, PLOTS, AND LYSIMETERS

To determine the inherent differences between the various small

watersheds, plots, and lysimeters and to calibrate them, one in terms of the other, the operations on them will be conducted in two stages to be known as FIRST STAGE and SECOND STAGE.

FIRST STAGE

During the first stage measurements of soil and water run-off, soil moisture and ground water, amount and intensity of precipitation, and of other meteorological factors will be made, during a period of normal climatic conditions, on the small watersheds, plots, and lysimeters. The treatment to be applied on them during this stage will be as follows:

Small Watersheds

Series A - on slopes of 20 percent and up

The timbered watersheds will be treated in accordance with prevailing practices.

All other watersheds will be pastured in accordance with best known practices.

Series B - on slopes 12 percent to 20 percent

All watersheds will be in crop rotation of corn, wheat, 3 meadow and will be plowed and cultivated on the contour.

Series C - on slopes up to 12 percent

All watersheds will be in crop rotation of corn, wheat, 2 meadow and will be plowed and cultivated on the contour.

Plots

All plots will be kept in wheat or in a good rotation.

Lysimeters

All lysimeters will be kept in fallow.

SECOND STAGE

During the second stage all the measurements on small watersheds, plots, and lysimeters mentioned under FIRST STAGE will be continued. The treatment to be applied to them during the SECOND STAGE will be as follows:

Small Watersheds

Series A - on slopes of 20 percent and up

1 Timbered watershed treated in accordance with prevailing practices.

1 Timbered watershed treated in accordance with best known practices.

1 Watershed in meadow, pastured in accordance with prevailing practices.

1 Watershed in meadow, not pastured.

1 Watershed in pasture, treated in accordance with prevailing practices.

2 Watersheds in pasture, treated in accordance with best known practices.

1 Watershed in pasture with contour furrows or terraced and pastured in accordance with best known practices.

Series B - on slopes of 12 percent to 20 percent

1 Watershed in small narrow base terraces with permanent grass strip on terrace ridge with a rotation of corn,

wheat, 3 meadow.

1 Watershed in rotation in accordance with prevailing practices.

2 Watersheds in rotation of corn, wheat, 3 meadow, to be cultivated and plowed on the contour.

1 Watershed in strip cropping with strips of equal widths and a rotation of corn, wheat, 3 meadow.

Series C - on slopes up to 12 percent.

2 Watersheds plowed and cultivated on the contour in rotation of corn, wheat, 2 meadow.

1 Watershed in broad base graded terraces with a rotation of corn, wheat, 2 meadow.

1 Watershed cropped, plowed, and cultivated in accordance with prevailing practices.

1 Watershed in strip cropping with equal strips and a rotation of corn, wheat, 2 meadow.

Plots

The treatment to be applied to the plots will be determined in the course of the studies and will conform with that on the small watershed.

Lysimeters

The treatment to be applied to the lysimeters will be determined in the course of the studies at the end of the first stage.

(E). Initial Basic Surveys

Complete initial basic surveys will be made of all the watersheds to obtain information needed in connection with studies relating to the following factors:

(1). Soil erosion survey, including regular soil survey.

(2). Topography and physiography.

(3). Geology.

(4). Land use including general cover, crops, and agricultural practices.

(5). Ground water.

(6). Economic and social conditions.

The land use survey will be repeated periodically and the other surveys whenever advisable or necessary.

Specifications for surveys and maps to be made on the watersheds are given below:

Specifications for Surveys and Maps

Aerial Surveys

1. Ground control to consist of a closed traverse following the boundary of the watershed. Maximum allowable error 1 in 5,000.

2. Vertical control: 12 to 15 B.Ms giving elevations to 1/100 of a foot should be established within each watershed. Maximum allowable error in leveling, 0.05 feet x $\sqrt{\text{distance in miles}}$.

3. Scale 1"=500 feet on master watersheds.

   1"=100 feet on small watersheds.

4. Topography

(a). On master watersheds.

Contour interval 5 feet. Where a 5 ft. contour interval is impractical 10 feet should be used. Contour lines to continue 200 feet beyond the boundary of the watershed. Maximum allowable error in topography not to exceed half of the contour interval. Maximum allowable error in locating individual features not to exceed 5 feet.

(b). On Small Watersheds and Plots.

Contour interval 5 feet on Series A, 2 feet on Series B, 1 foot on Series C. Maximum allowable error not to exceed half of the contour interval. Maximum allowable error in locating individual features not to exceed 2 feet.

Soil Surveys

(a). Master Watersheds.

Detailed soil surveys should meet the specifications of the Bureau of Chemistry and Soils and Soil Conservation Service. They should give soil profiles and information on the depth of the soil.

(b). Small Watersheds and Plots.

Detailed soil surveys as above, supplemented by frequent analysis of soil samples.

Erosion Surveys

(a). Master Watersheds.

Erosion surveys should conform with the highest standards in use at the present time.

(b). Small Watersheds.

Detailed erosion surveys giving nature of sheet erosion and dimensions and location of gullies.

Land Use and Vegetative Surveys

(a). Master Watersheds.

With the topographic map (1"=500 ft.) as a base, accurate land use and vegetative surveys will be made giving the type of timber and litter, crops, and grasses.

(b). Small Watersheds and Plots.

Accurate vegetative surveys will be made on the lysimeters, plots, and small watersheds. It is proposed to use transects and the "frequency index" method of Raunkiaer. This method has been tested by W. G. McGinnies of the University of Arizona and was found satisfactory. (See "The relation between frequency index and abundance as applied to plant regulations in a semi-arid region" Ecology, Vol. 13, No. 3).

Geology

Geologic surveys will include a sufficient number of geologic sections and columns for each watershed, and a map of geological structure and formations.

Ground Water

An initial survey of drilled observation wells should furnish information on the initial depth of the water table and ground water. The measurements will be made to the nearest 1/100 of a foot, and will otherwise conform with the Manual of instructions recently prepared by the Ground Water Division of the U. S. Geological Survey.

Economic and Social Survey

A census of the economic and social conditions of the farms located within Q and the intermediate watersheds adjacent to it is proposed to be made in cooperation with the Bureau of Agricultural Economics and the University of Ohio.

Maps and Information to be Secured

The surveys should yield the following maps and information:

1. Aerial Prints.
2. A controlled mosaic of the major watershed on a scale of 1"=500 feet.
3. Planimetric maps on a scale of 1"=500 feet for major watersheds.
4. Planimetric maps on a scale of 1"=100 feet for small watersheds.
5. Contour maps on a scale 1"=500 feet, contour intervals, 5 feet for major watersheds.
6. Contour maps on a scale 1"=100 feet, contour intervals 2 and 1 ft. on small watersheds.

7. Detailed soil maps using the contour maps as a base for major and small watersheds.

8. Detailed erosion survey maps using the contour maps as a base for major and small watersheds.

9. A soil survey report.

10. An erosion survey report.

11. A geologic map and geologic sections and columns for the major watersheds.

12. Well logs from drilled observation wells and initial depths to water on all wells on the watersheds.

13. A census report.

(F). Field Procedure and Measurements

Precipitation

(1). About two hundred standard rain gages will be distributed over the watersheds Q and Q', and the intermediate watersheds adjacent to Q. Twenty recording rain gages equipped with clocks will be installed at strategic points on the watersheds for the purpose of measuring the intensity, in addition to amount, of precipitation. During the winter months the gages will be equipped with shields for measuring snowfall. Snow boards and snow scales (pegs) will be installed in conjunction with each rain gage.

The number of gages, both standard and recording, is subject to revision in the light of analysis of data collected from them during a normal season of precipitation.

Such revision would be based upon the amount of variation about a mean.

A few recording and standard gages will be installed on Watersheds M, 8, W", and V (See Figure #1). It is expected that the Muskingum Watershed Conservancy District will furnish the equipment and the observers on the four supplemental watersheds mentioned above.

Meteorological Stations.

Two complete central meteorological stations - each consisting of:

1. Standard Weather Bureau Class A evaporation pan complete with:
   a. Evaporation pan
   b. Still well
   c. Hook gage
   d. Anemometer
   e. 2 sets of Maxima and Minima Thermometers
   f. Psychrometer
2. Barometer
3. Recording rain gage
4. Standard rain gage
5. Wind vane
6. Hygrothermograph
7. Soil thermograph
8. Sunshine duration transmitter

9. Combined recorder

10. Solar radiation thermometer

11. Instrument shelter

In addition to the central meteorological stations two sub-stations will be established - each consisting of:

1 Soil thermograph

1 set of Maxima and Minima thermometers

1 Recording rain gage

1 Solar Radiation thermometer

To supplement the records from the soil thermographs, thermocouples will be used on the small watersheds, plots, and lysimeters.

The recording rain gages to be installed on the central meteorological stations and on the sub-stations are included in the total of twenty.

Ground water and soil moisture

Ground water:

Fifty ground water observation wells will be drilled; of these, 10 will be on Q' and the rest on Q. Of the total number, 10 wells will be equipped with stage recorders giving a continuous hydrograph.

Soil moisture:

Soil samples will be taken and the moisture determined gravimetrically in the laboratory. The records obtained from the samples will be supplemented by records obtained with the electrical method (See "New Method of

Measuring the Aqueous Vapor Pressure of Soils" by N. E. Edlefson, Soil Science, Vol. 38, Pages 29-35, Date July, 1934) and by the "Tensiometer" developed by L. A. Richards and Willard Gardner. (See "Capillary Action in Soil and the Use of Porous Ceramic Ware in the Measurement of Soil Moisture", contributions from the Department of Physics, Cornell University and Soil Physics Laboratory, Utah Agricultural Experiment Station).

It is proposed to compare the two methods mentioned above with the actual determinations from soil samples and if possible, adopt one of the two.

Infiltration and Percolation Rates

Apparatus devised by G. W. Musgrave, described in "Infiltration Capacity of Soils", Journal of the American Society of Agronomy, Vol. 27, No. 5, 1935, and used on the Clarinda S.C.S. Experiment Station will be used in comparing the infiltration and percolation rates through the soil on the various plots, small watersheds, and on the intermediate watersheds. The device is shown in Figure #3-A&B. A number of lysimeters of the type shown in Figure #4 will be used in determining the amount of percolation and the amounts and rates of seepage, as well as surface run-off from small areas under control conditions.

The final designs to fit local conditions will be developed and the number of installations will be determined after the surveys have been made.

Transpiration and Evaporation Losses from Soils

A battery of 10 to 15 Mariotte constant water table tanks located in the vicinity of the headquarters will be used. A typical installation of such tanks is shown in Figures 5-A, B&C. Livingston porous cup atmometers shown on Figure #6 will be used to supplement the data on the evaporation from soils.

Evaporation from Water Surfaces

Evaporation will be measured by means of the two U.S.W.B. Class A evaporation pans described under "Central Meteorological Stations", and additional insulated evaporation pans.

Amounts and Rates of Surface Run-off will be measured from:

(a). Large lysimeters by means of tanks equipped with stage recorders as shown in Figure #4.

(b). Small plots by means of metal or concrete tanks equipped with stage recorders or the Lowdermilk Tipping Bucket where feasible. Design of the Lowdermilk Tipping Bucket is given in Figure #7.

(c). Larger plots by means of installations consisting of:

1. Small Parshall flume.
2. Silt box.
3. The Geib Divisor or the Ramser silt sampler.

Typical designs and installations of the above are given in Figures #8-A,B,C,D,E,F,G,H,I&K.

(d). Small watersheds by means of:

1. Parshall flumes

2. Ramser silt sampler

Typical designs and installations of the above are given in Figures #8-A,B,C,D,E,F,G,H,&I.

(e). Intermediate watersheds by means of:

1. Large reinforced concrete Parshall flumes
2. Tait and Binckley silt samplers
3. Detritus basins to measure bed load

Typical designs and installations of the above are given in Figures #9-A,B,&C.

The tentative locations of the gaging sites are given in Figure #2.

(f). Major watersheds

1. Standard U.S.G.S. cable or bridge gaging stations equipped with waterstage recorders.
2. Price current meters.
3. Tait and Binckley silt samplers.

Typical designs and installations of the above are given in Figures #10-A,B,C,D,E, F, G and 9-B.

Tentative locations of gaging sites are shown in Figure #2.

"Time of Concentration"

The time of concentration for the various watersheds will be determined from velocity measurements of floats and dyes in the watercourses, from studies of waterstage hydrographs at the gaging stations, and possibly by other methods to be developed in the course of the studies.

Laboratory Determinations of silt content and soil moisture will be made in a central soil and hydrologic laboratory to be located at the headquarters which will be equipped with:

1 Constant temperature oven

4 Dessicators

1 Analytical balance

1 Torsion balance

1 Mechanical shaker

1 Elutriator

1 Vacuum pump

Glassware

Chemical reagents

Other equipment as needed.

A tentative design of the laboratory is given in Figure #11-A.

Construction, Management, and Farm Operations

All operations including construction, observations, management, and farm operations on the small watersheds will be conducted from a central headquarters, the tentative location of which is given in Figure #2.

The headquarters will consist of:

(a). Office and laboratory building including instrument room.

(b). Utility building containing garage, machine shop, machinery shed and central heating plant.

(c). Superintendent's residence.

(d). Farm foreman's residence.

(e). Staff quarters.

The headquarters consisting of the buildings listed above and the plots and lysimeters will be centrally located with respect to the small watersheds as indicated in Figure #2.

Note: The Staff quarters will contain a dining room for the members of the staff retained on night duty during storms. Tentative designs of the various buildings are given in Figures #11-A,B,C,&D.

(G). Tentative Plan of Operations

(1). Immediately upon the approval of this project the necessary arrangements will be made for:

(a). A detailed topographic survey of the territory involved.

(b). The purchase of the land needed for the headquarters.

(c). The purchase or 20-year lease of the small watersheds.

(d). Signing of cooperative agreements with farmers and landowners on the Q watershed.

(The legal and land appraisal staff of the Muskingum Watershed Conservancy District are making preliminary studies of the possibilities of securing control of the land).

(2). A system of all-weather roads necessary in servicing the various gaging stations and installations will be constructed and the existing roads will be improved for all-weather services.

(3). All basic initial surveys.

(4). Supplemental working plans will be prepared for each phase of the study, to include layout, drawings of installations, procedure in experimentation, and in recording experimental data. The supplemental working plans on approval by the Chief of the Division of Research will become a part of this master working plan and will determine the experimental procedure until approved revisions are made in response to new findings.

(5). The standard rain gages will be installed at tentative locations in order to determine the nature and distribution of precipitation.

(6). The lysimeters and plots with all the necessary installations will be designed and constructed.

(7). The final selection of the small watersheds will be made and the necessary installation constructed.

(8). The gaging stations on the intermediate and master watersheds will be constructed.

(9). The headquarters buildings will be constructed.

(10). The standard equipment will be purchased and special equipment will be designed.

(11). The cropping program called for during the first stage on the small watersheds, plots, and lysimeters will be inaugurated.

(12). Farm operation programs will be prepared for the cooperators on watershed Q in accordance with the cooperative agreement.

VIII. COOPERATION

The close cooperation of the other subdivisions of the Division of Research of the Soil Conservation Service will be sought in all matters relating to their fields of work.

It is proposed to establish cooperative relations with all Federal Bureaus, State Experiment Stations, Colleges, Hydraulic Laboratories, and other public and private agencies engaged in lines of work related to the studies to be conducted on the watersheds.

Where deemed necessary and in the public interest, outstanding authorities on the various phases of the work will be engaged as consultants.

In the North Appalachian Region the following specific cooperative arrangements will be made:

1. The Regional Advisory Council on Soil Conservation will act in an advisory capacity particularly with respect to the methods of erosion control to be used within Watershed Q.
2. The Regional Director of the Soil Conservation Service, or members of his staff designated by him, will draw up, in consultation with the Head of the Watershed Studies, and carry out actual plans of farm operations and land use to be incorporated in the cooperative agreements with farmers on the intermediate watersheds within the Q Watershed on an experimental basis.

3. The Muskingum Watershed Conservancy District agrees to:

   (a). Make arrangements for securing the necessary control of the land for the headquarters, plots, lysimeters, small watersheds, and gaging sites.

   (b). Cooperate in making the topographic and other surveys on the watersheds.

   (c). Supply the equipment and observers on the Watersheds M, 8, V and W".

   A letter from the Board of Directors of the Districts offering the cooperation of the District is given on Page 2 of this plan. Mr. Browning, Secretary and Treasurer of the M.W.C.D., is now making preliminary arrangements with regard to securing control of the land.

4. The State Geologist of Ohio, (Mr. Stout), will advise and assist in making the necessary geologic surveys of the Watersheds. (Mr. Stout advised Mr. Krimgold in the selection of the watershed and reviewed the preliminary report on the geology of the watersheds Q, Q', L, L', W, and W").

5. Cooperative arrangements will be made with the Geological Survey and other Agencies with regard to silt sampling at gaging stations on larger streams.

6. Mr. Leach, collaborator for the Branch of Research of the S.C.S., will be consulted in the various phases of the work.

7. Arrangements will be made with the Geological Survey by which Mr. O. E. Meinzer of Ground Water Division will serve as consultant in the Ground Water phase of the work and will advise in the location of ground water observation wells.

IX. PROPOSED EXPENDITURES

The proposed expenditures given below are divided into two major groups, (A) Initial Expenditures; (B) Operating Costs.

(A). Initial Expenditures

Labor:

Technical and Professional labor	$ 3,320	
Skilled labor	21,900	
Intermediate labor	18,600	
Unskilled labor	47,520	
Total labor		$91,340

Equipment, Supplies, and Materials:

Materials for buildings	$17,000

Gaging Stations, Materials, and Equipment:

4 Large Cable Stations	4,800
6 Bridge Stations	5,400
20 Large Parshall Concrete Flumes	9,600
25 Parshall Flumes and Silt Samplers ..	12,000
10 Current Meters	900
Materials for 50 Ground Water Wells ..	1,500
Equipment and Materials for Lysimeters	8,000

Equipment and Materials for Plots ..	$ 5,400
Surveying Instruments:	
2 Transits	600
3 Engineer Levels	450
6 Level Rods	120
1 Plane Table with Telescopic Alidade	300
Meteorologic Equipment:	
20 Recording Rain Gages	4,000
200 Standard Rain Gages	1,400
2 W.B. Insulated Pans	100
2 Still wells	64
2 Hook Gages	160
2 Anemometers	156
2 Hygrothermographs	330
2 Maxima and Minima Thermometers	30
2 Psychrometers	30
2 Barometers	100
2 Shelters	50
4 Soil Thermographs	530
2 Combined Recorders	920
2 Sunshine Duration Transmitters	160
2 Solar Radiation Thermometers	30
Soil and Hydrologic Laboratory Equipment:	
Constant Temperature Oven	150
4 Dessicators	60
Analytical Balance	250

Glassware	$ 300
Mechanical Shaker and Elutriator ...	500
Chemical Reagents	50
Vacuum Pump	100
Torsional Balance	40

Machinery, Trucks, and Cars:

2 Pickup trucks	1,000
2 Sedan Delivery Trucks	1,200
2 Coupes	1,000
2 Coaches	1,000
2 Two-Ton Dump Trucks	2,000
1 Two-Ton Station Truck	1,000
1 Station Wagon	650
2 - 30 H.P.Diesel Tractors.......... (Crawler Type)	6,000
2 General Purpose Tractors	1,600
2 - 10' Blade Terrace Road Graders...	1,800
Farm Machinery	2,000
Miscellaneous	730

Total - Equipment, Supplies, and Materials ....$ 95,560

Total Initial Expenditures $186,900

(B). Operating Costs

(1). Personal services:

Professional services:

Grade 5. Superintendent .... 1 .. $3,800

Grade 3. Assoc.Hydraulic Engineer ...	1 ...	$3,200	
Assoc.Agricultural Engineer.	1 ...	3,200	
Assoc.Soil Technologist	1 ...	3,200	
Assoc.Forester	1 ...	3,200	
Grade 2. Ass't Hydraulic Engineer ...	1 ...	2,600	
Ass't Soil Technologist	1 ...	2,600	
Sub-professional services:			
Grade 4. Ass't Agricultural Aides ...	5 ...	8,100	
Farm Foreman	1 ...	1,620	
Clerical, Administrative, Fiscal:			
Grade 4. Clerk Stenographer	1 ...	1,800	
Grade 2. Junior Stenographer	2 ...	2,880	
Custodial:			
Grade 8. Skilled Mechanic	1 ...	2,000	
Total Personal Services			$38,200

(2). Other Expenditures:

Rents	$ 2,700
Repairs	3,000
Communication Service	800
Travel Expenses	2,000
Transportation of Things	1,000
Printing Photography	500
Surveys - Three Watersheds, 1936 and Two Watersheds 1937 at $3,500 per Watershed	3,500
Special and Miscellaneous	1,000

Total for Other Expenditures $14,500

Total for Operating Costs 52,700

Note: It is intended to utilize 154-man-years of Relief labor during the fiscal year of 1936. With the allowance of $1,080 per man-year, a total of $166,320 of Emergency Relief Funds will be available for labor and materials to be used during the fiscal year of 1936.

X. ASSIGNMENT

The studies will be carried out by the field personnel, (W. D. Ellison, Superintendent), under the direction of Mr. C. E. Ramser and the Washington Staff of the Division of Watershed and Hydrologic Studies.

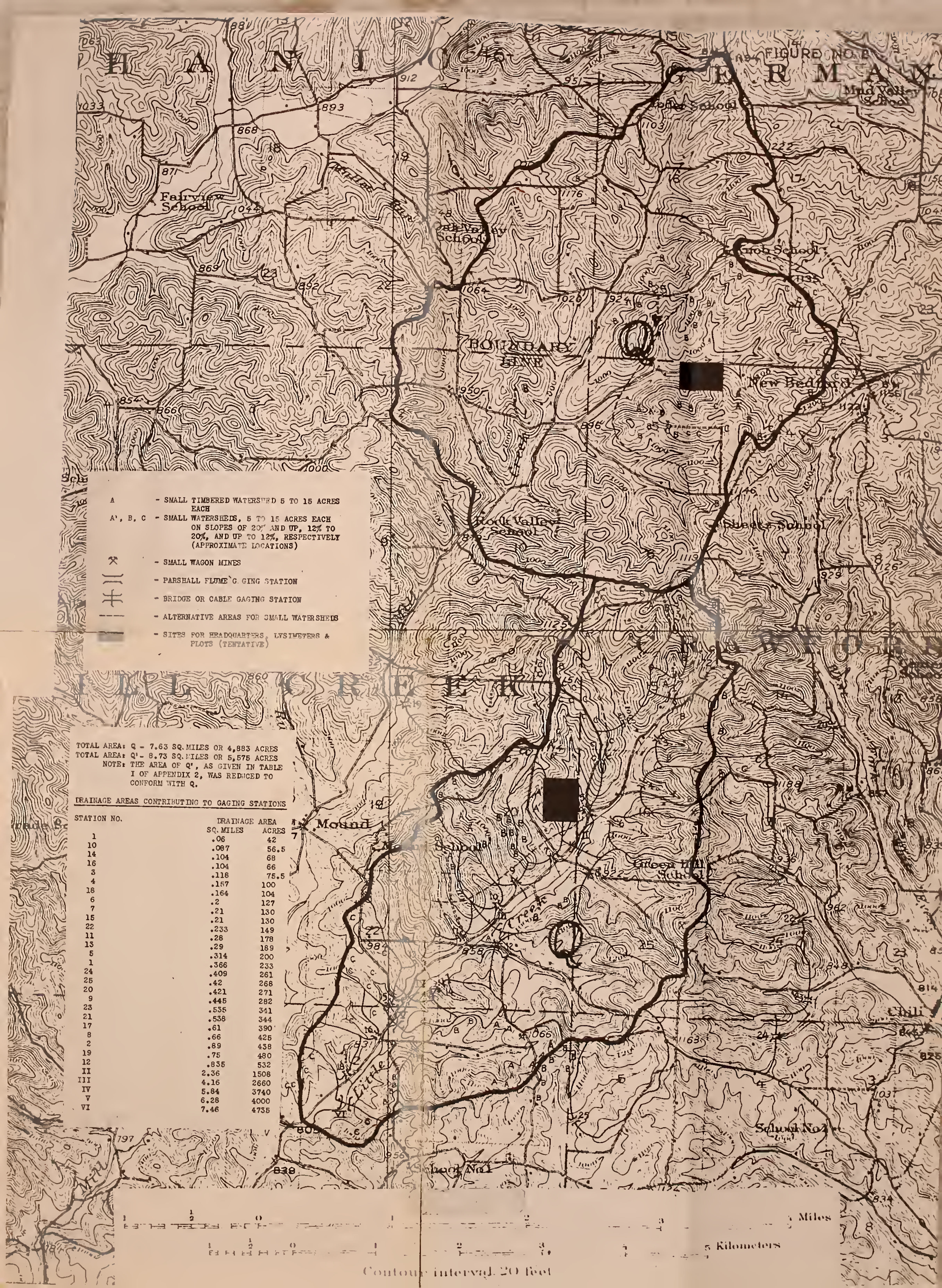
Organization charts for the section of Watershed and Hydrologic Studies and for one Experimental Watershed are given in Figures 12-A and 12-B.

FIGURES

Detailed Working Plan

SERIAL NO 67 FILE NO MR-18/1 EXHIBIT NO. 1

Figure 1



DRAINAGE AREAS CONTRIBUTING TO GAGING STATIONS

STATION NO.	DRAINAGE AREA SQ. MILES	DRAINAGE AREA ACRES
1	.06	42
10	.087	56.5
14	.104	68
16	.104	66
3	.118	75.5
4	.157	100
18	.164	104
6	.2	127
7	.21	130
15	.21	130
22	.233	149
11	.28	178
13	.29	189
5	.314	200
1	.366	233
24	.409	261
25	.42	268
20	.421	271
9	.445	282
23	.535	341
21	.538	344
17	.61	390
8	.66	425
2	.89	438
19	.75	480
12	.835	532
II	2.36	1508
III	4.16	2660
IV	5.84	3740
V	6.28	4000
VI	7.46	4735

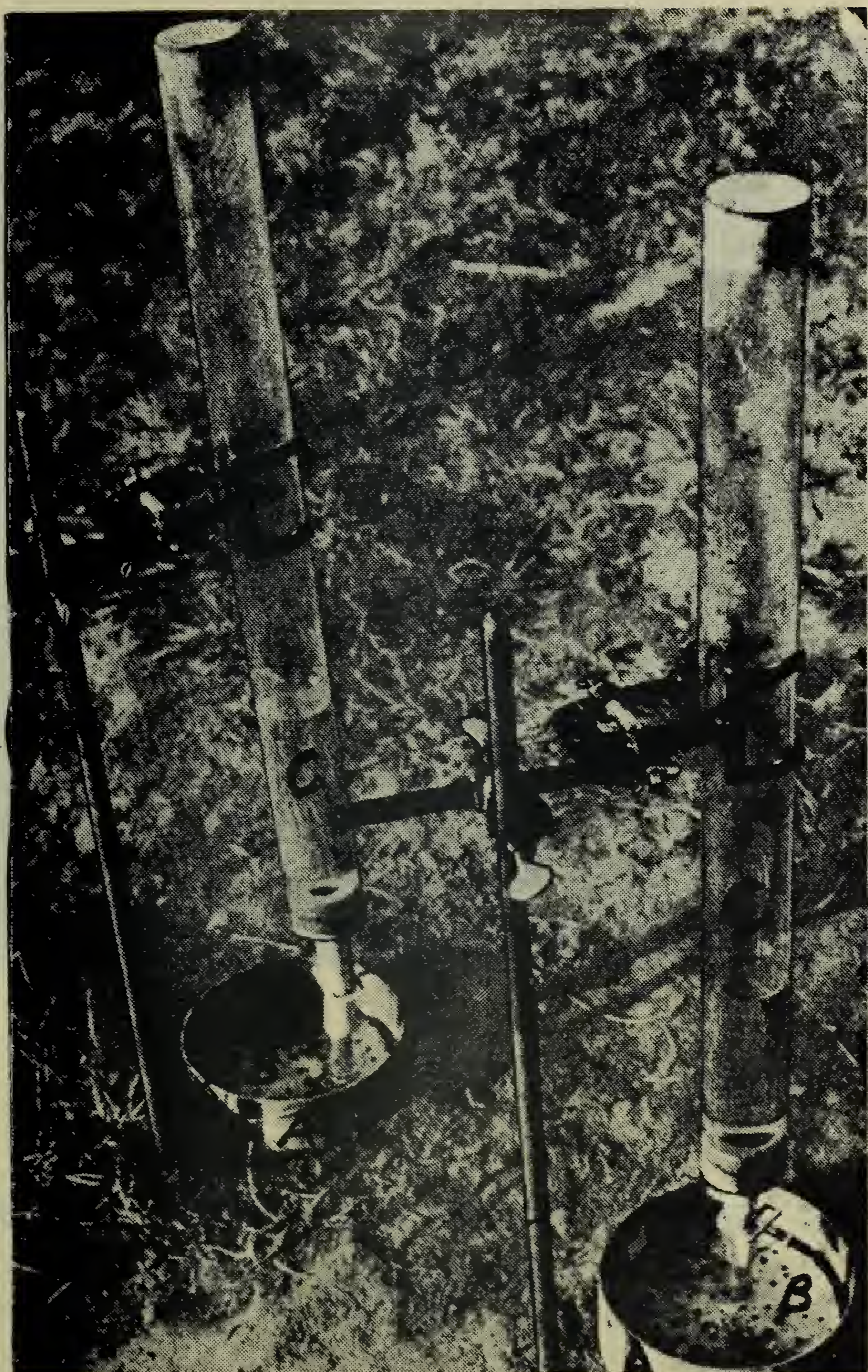


FIGURE 3-A

DETAIL VIEW OF INFILTRATION APPARATUS AS DEVISED
BY
MUSGRAVE AT CLARINDA, IOWA

FIGURE 3-B

GENERAL SETUP OF INFILTRATION APPARATUS AS DEVISED
BY
MUSGRAVE AT CLARINDA, IOWA

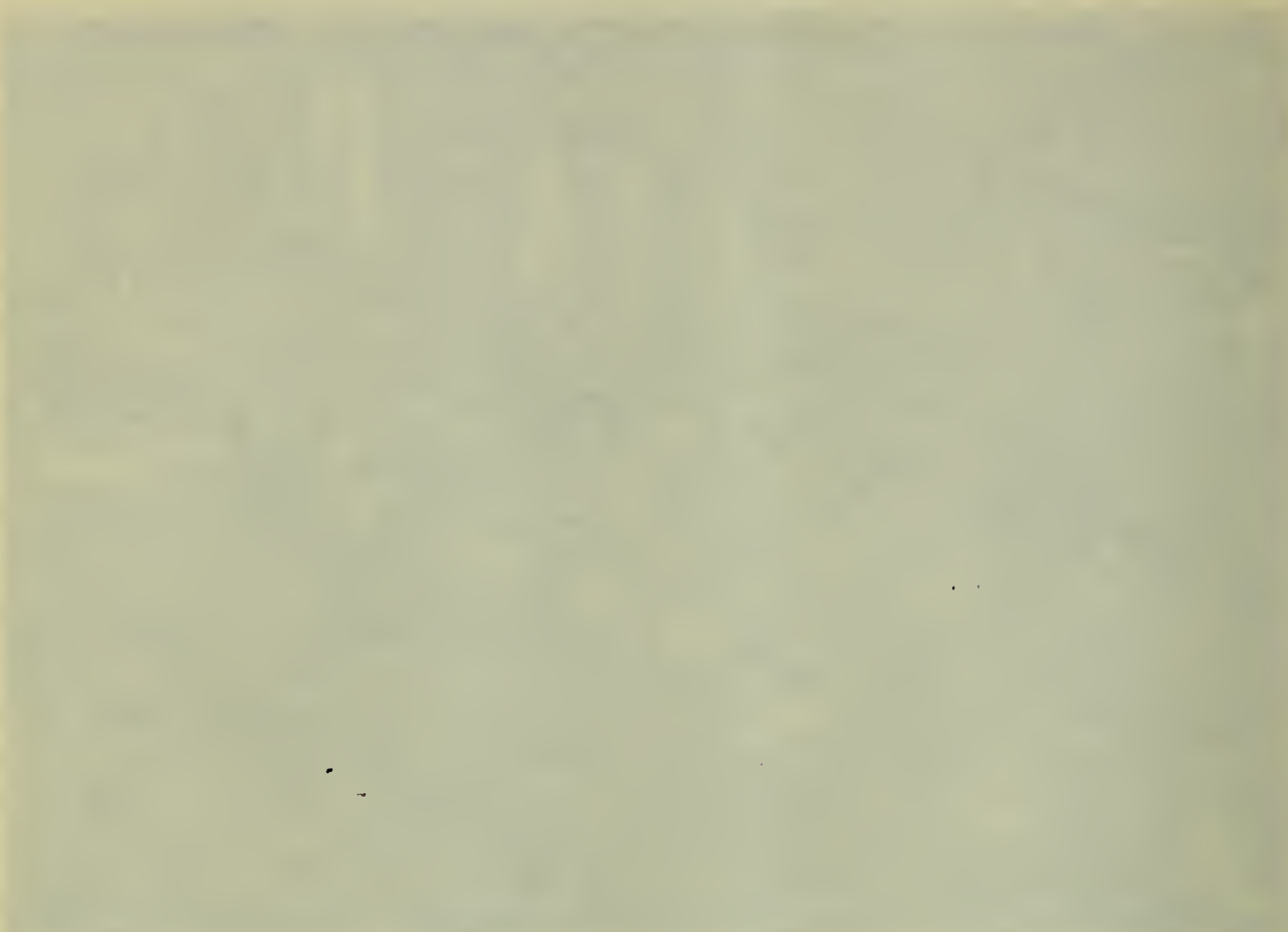
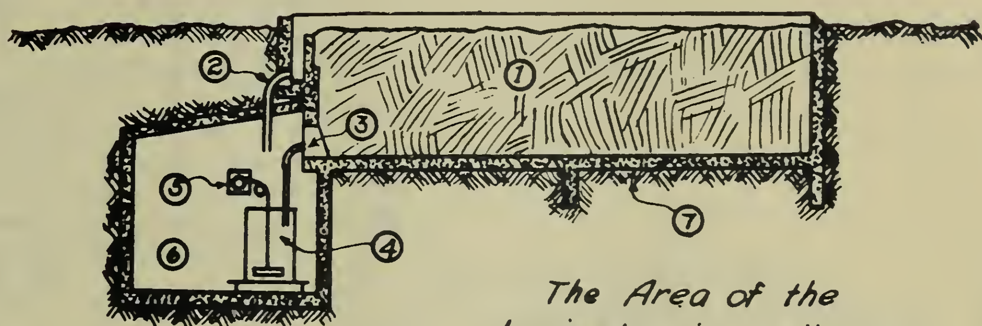


Diagram Figure No. 4

Cross Section of a single Tree Lysimeter



The Area of the Lysimeter is 5 Milacres.

① Soil Mass in Lysimeter.

② Runoff pipe.

③ Seepage pipe

④ Collector tank, One for each pipe

⑤ Intensity recording Instrument

⑥ Collector tunnel

⑦ Concrete Walls

FIGURE 4

LYSIMETER

FIGURE 5-A

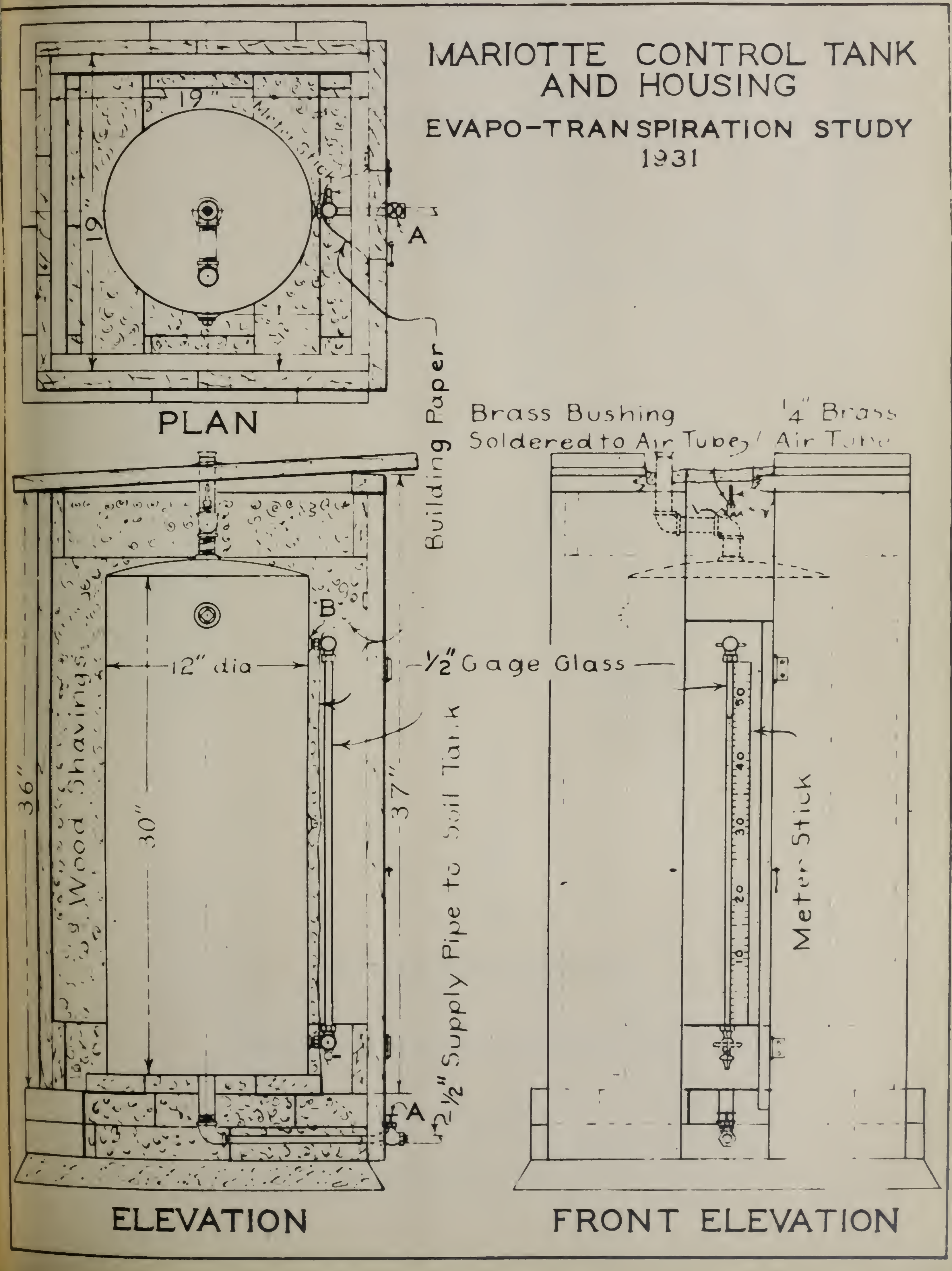

MARIOTTE CONTROL TANK
AND HOUSING
EVAPO-TRANSPIRATION STUDY
1931
19"
19"
A
Building Paper
PLAN
Brass Bushing
Soldered to Air Tube
1/4" Brass
Air Tube
B
12" dia
1/2" Gage Glass
Wood Shavings
36"
30"
37"
2 1/2" Supply Pipe to Soil Tank
Meter Stick
50
40
30
20
10
A
ELEVATION
FRONT ELEVATION

FIGURE 5-B

MARIOTTE REGULATION FEED TO SUPPLY EVAPO-TRANSPIRATION LOSS FROM SOIL TANKS

IRRIGATION INVESTIGATIONS
U S DEPT. AGRI. COLO. EXPT. STATION
FORT COLLINS. COLORADO.
JANUARY 1932

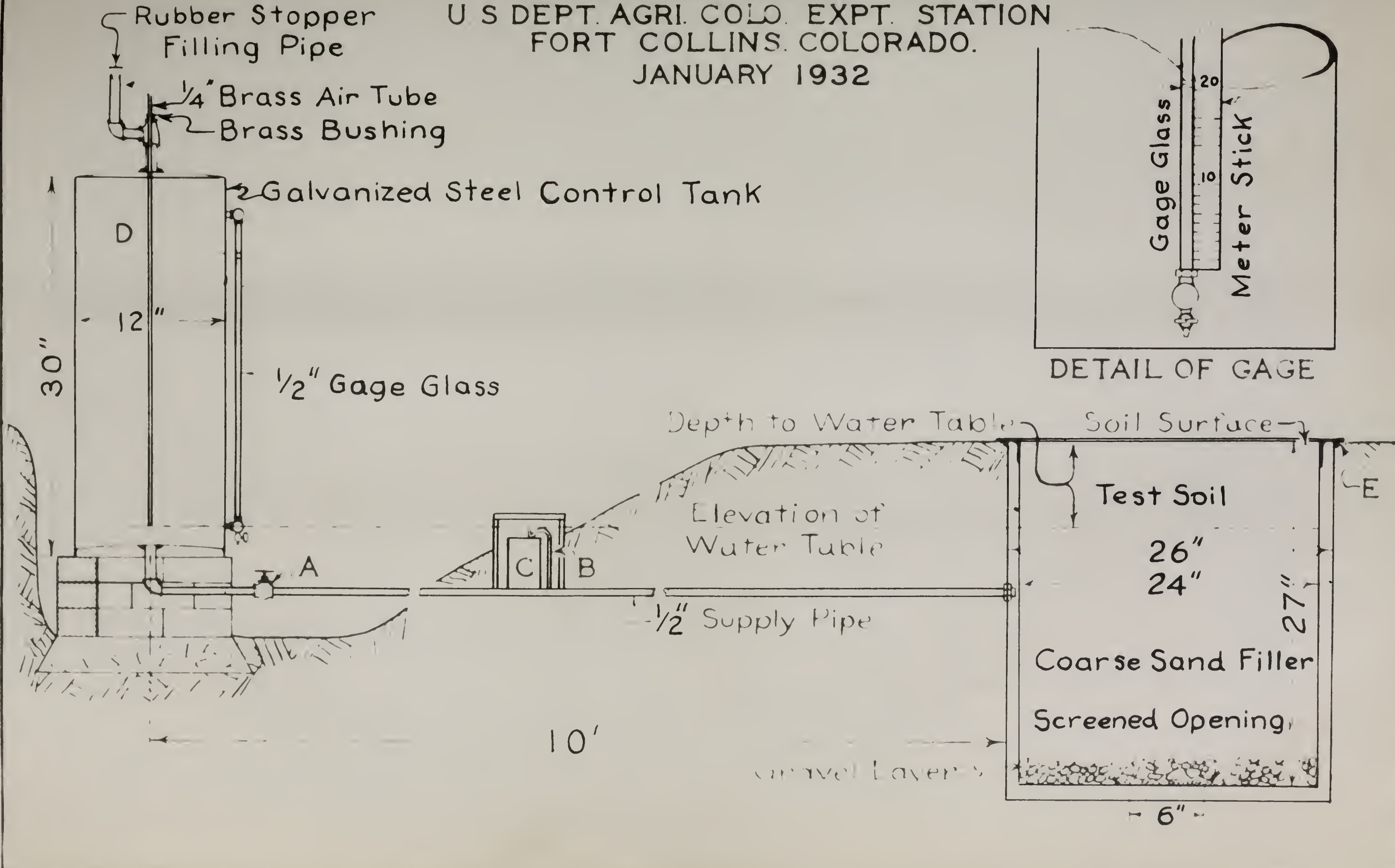


FIGURE 5-C

PLAN OF APPARATUS EVAPO-TRANSPIRATION STUDY

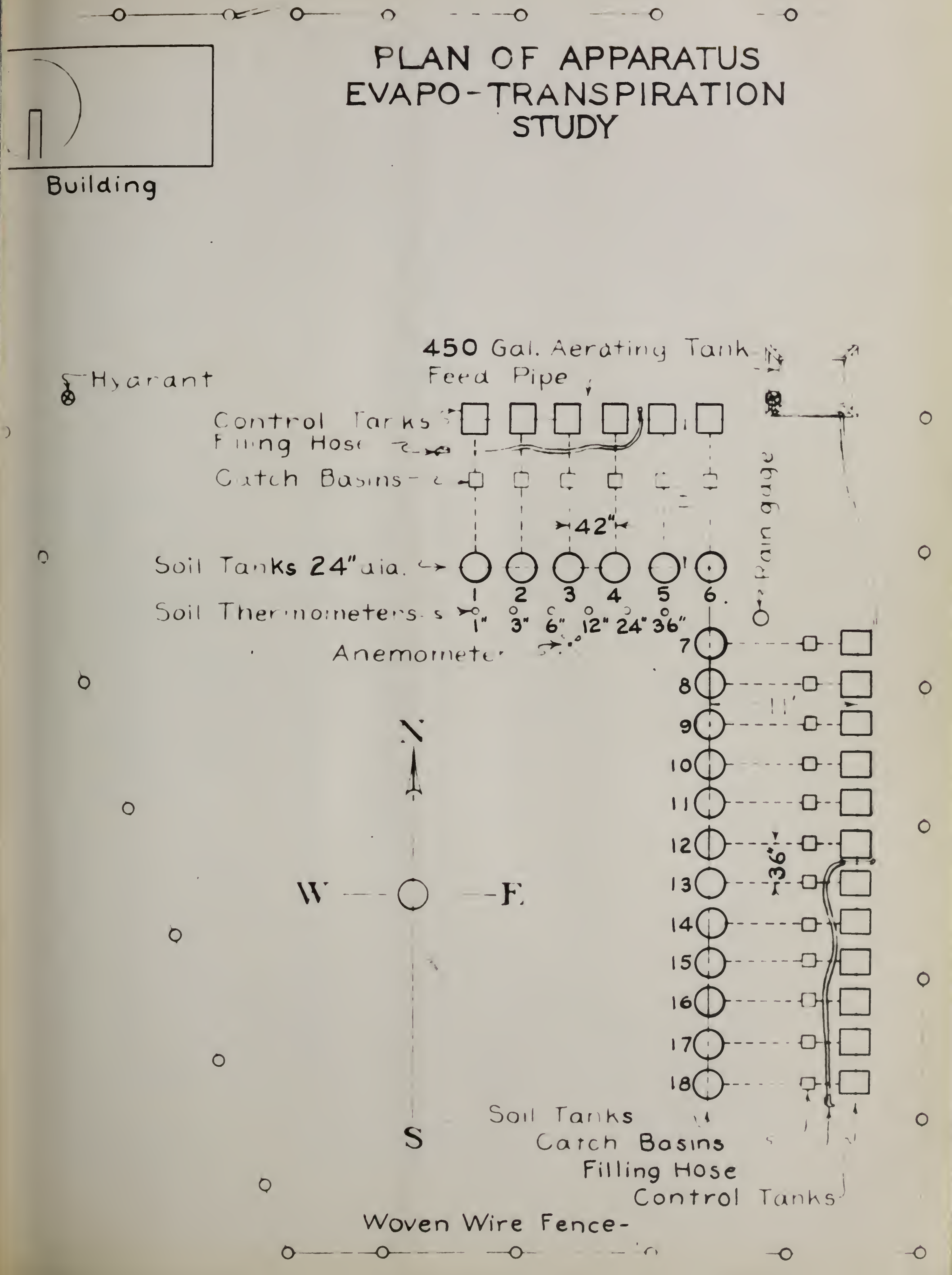


FIGURE 6

Porous-porcelain Atmometers
(B.E.L.)

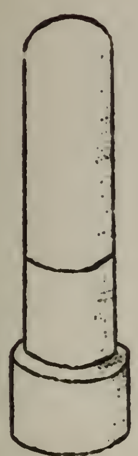


Fig. 1
Cylinder

Fig. 2
Sphere

Fig. 3
Bellani Plate

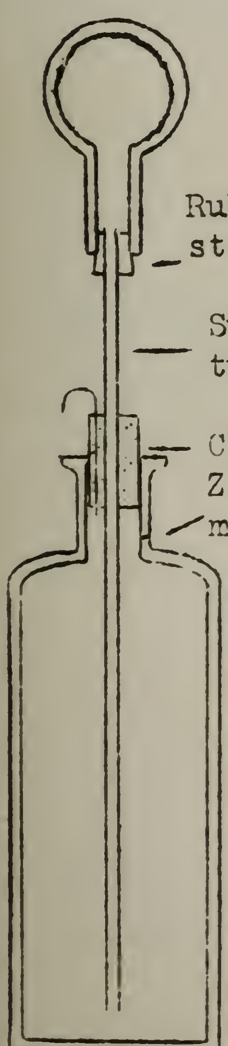


Fig. 4
Simple mounting
for bottle.

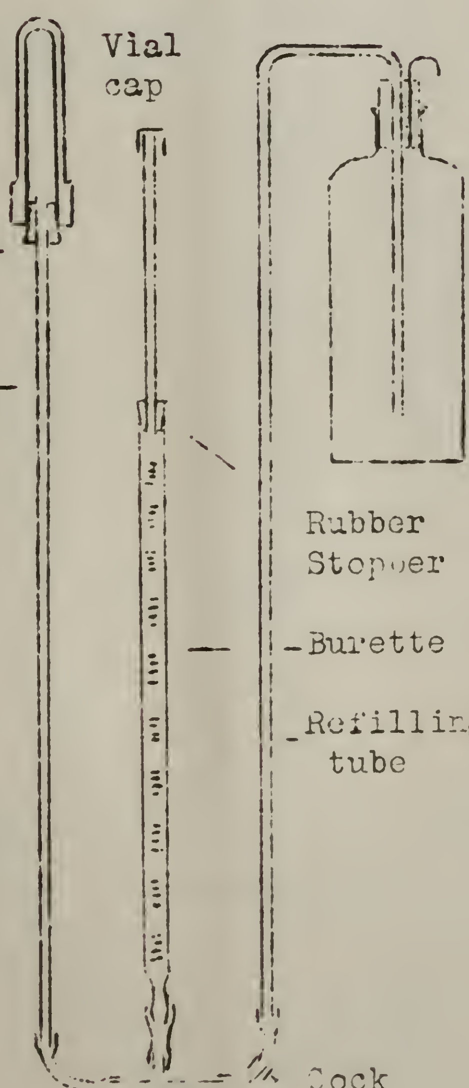
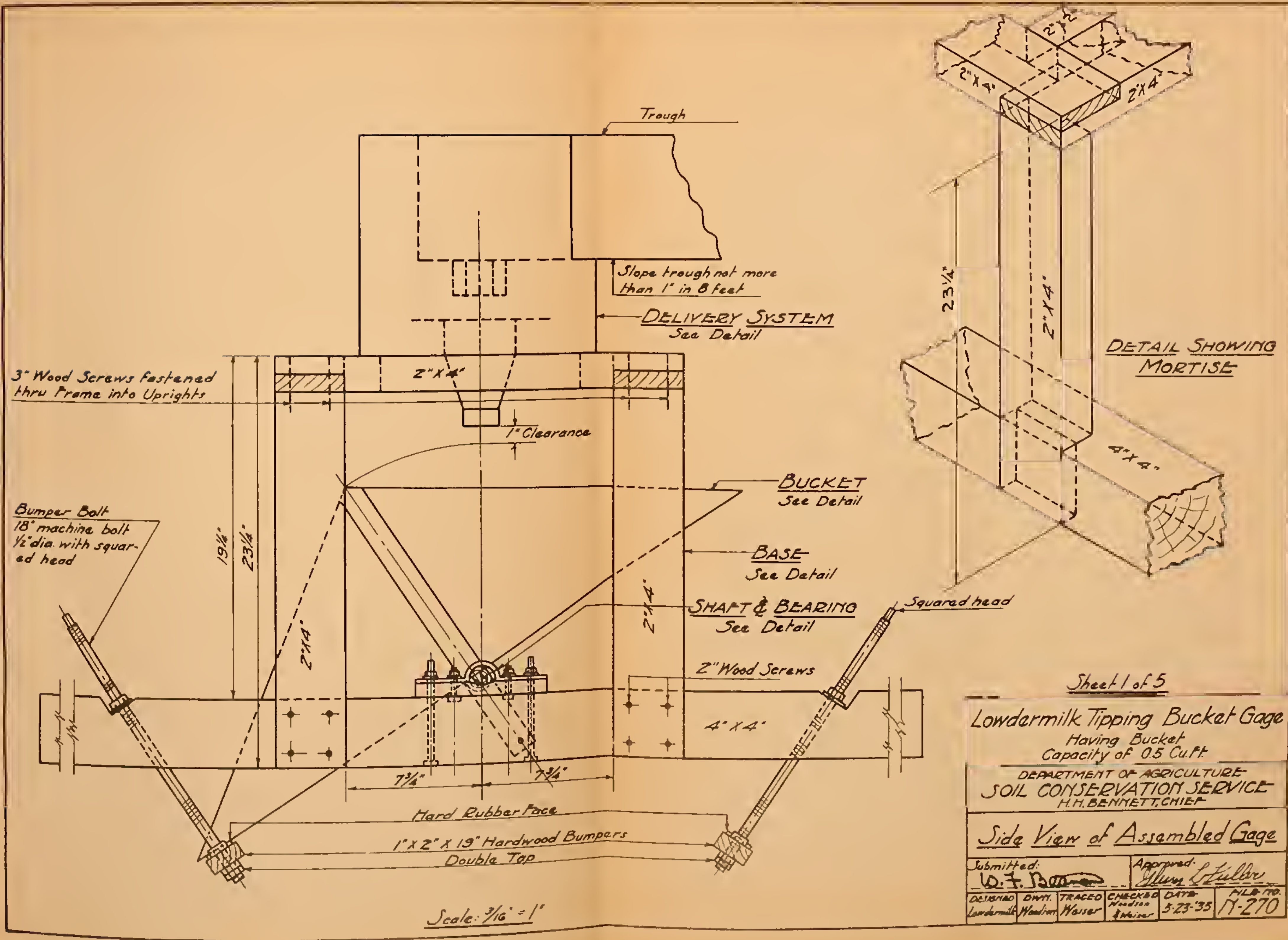


Fig. 5
Simple mounting
for burette.

Fig. 6
Livingston-Thone
non-absorbing
valve.

-54-

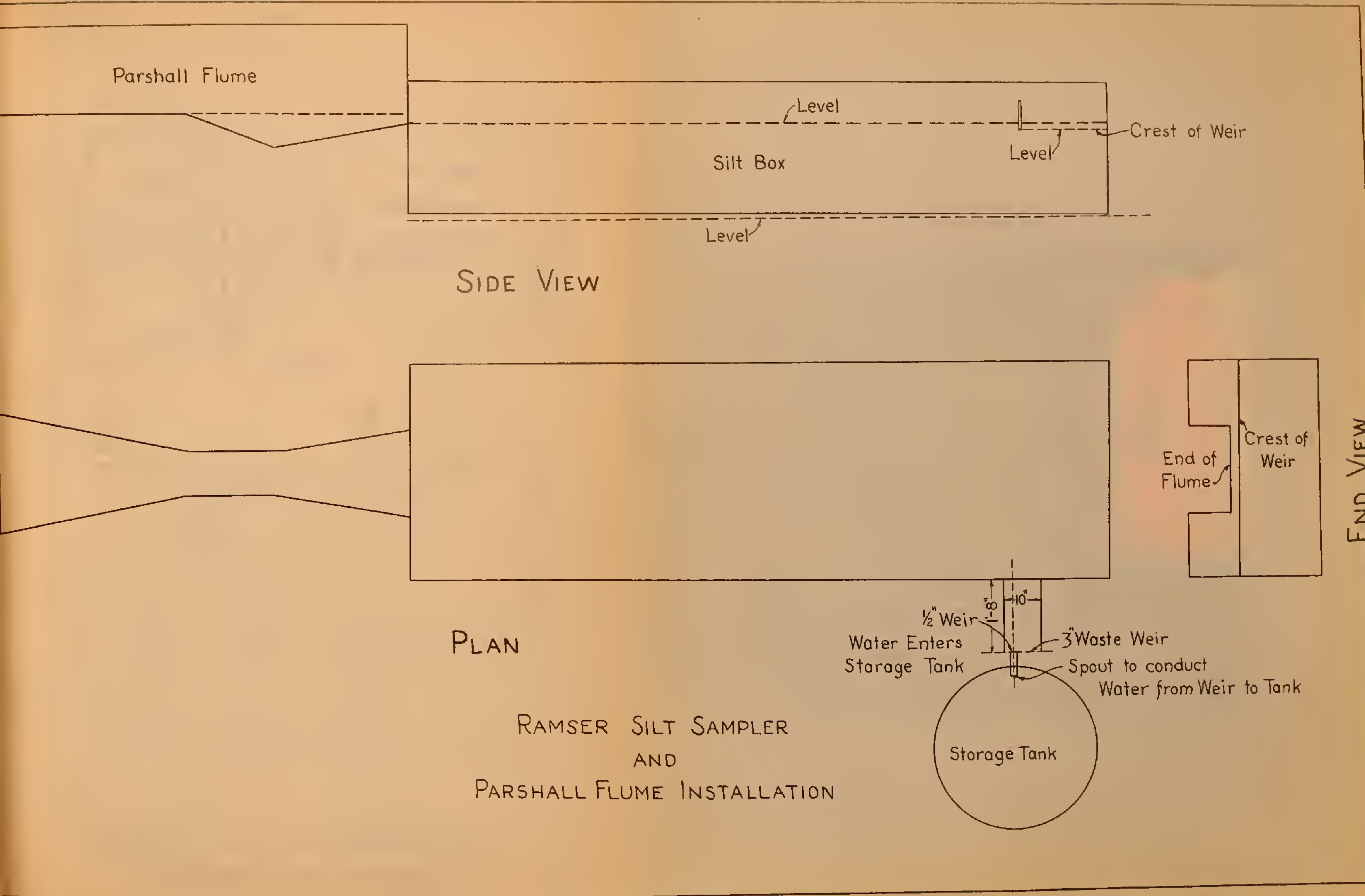
Fig. 7



Trough
Slope trough not more than 1" in 8 feet
DELIVERY SYSTEM
See Detail
2"X4"
3" Wood Screws fastened thru Frame into Uprights
1" Clearance
BUCKET
See Detail
BASE
See Detail
SHAFT & BEARING
See Detail
Bumper Bolt
18" machine bolt ½" dia. with squared head
19¼
23¼
2"X4"
2"X4"
Squared head
2" Wood Screws
4"X4"
7¾"
7¾"
Hard Rubber Face
1"X2"X19" Hardwood Bumpers
Double Tap
Scale: 3/16" = 1"
2"X2"
2"X4"
2"X4"
23¼"
2"X4"
DETAIL SHOWING MORTISE
4"X4"
Sheet 1 of 5
Lowdermilk Tipping Bucket Gage
Having Bucket
Capacity of 0.5 Cu.Ft.
DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H.H. BENNETT, CHIEF
Side View of Assembled Gage
Submitted:
Approved:
DESIGNED Lowdermilk
DWN. Woodson
TRACED Weiser
CHECKED Woodson & Weiser
DATE 5-23-35
FILE NO. M-270

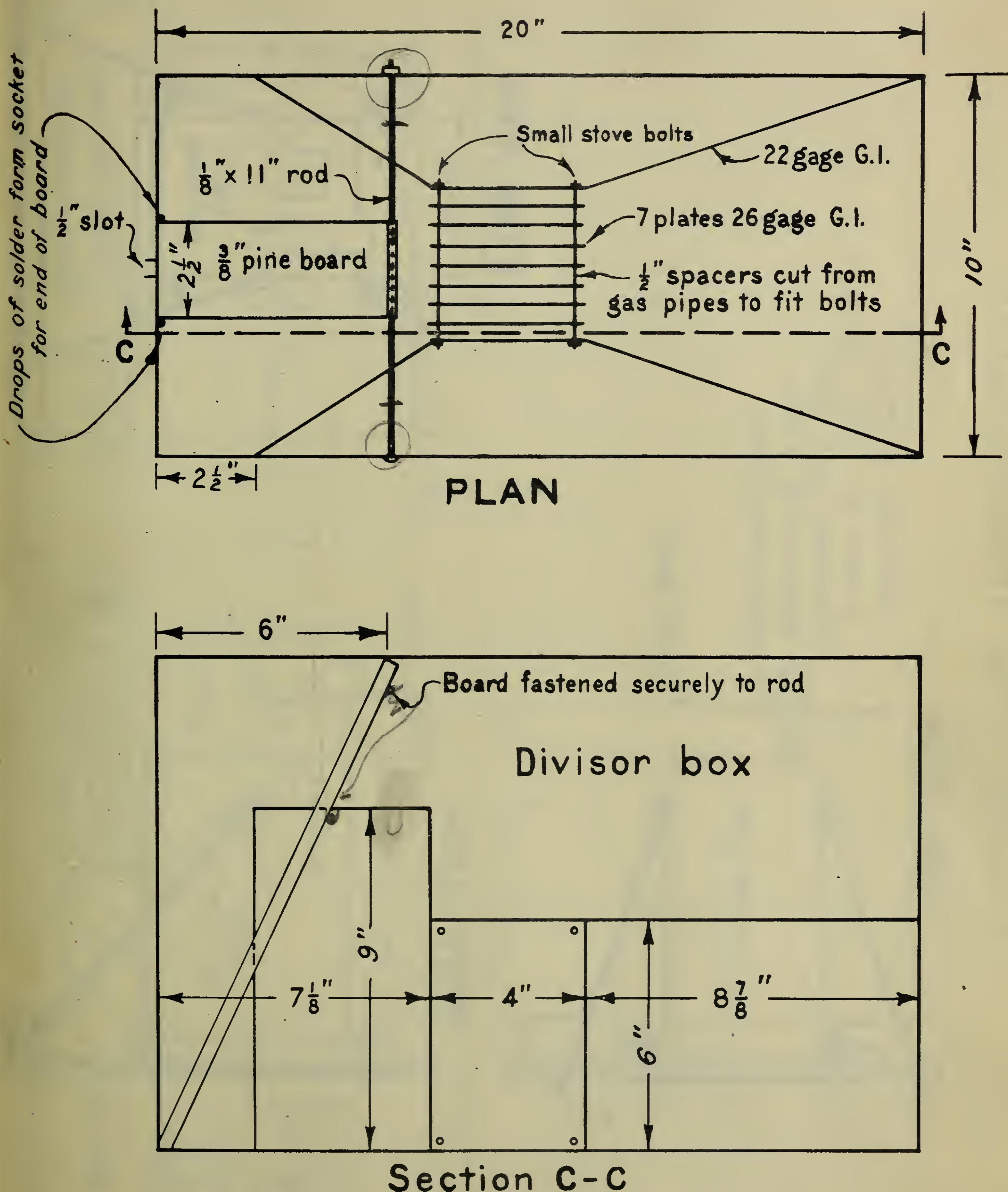
-55-

FIGURE 8-A



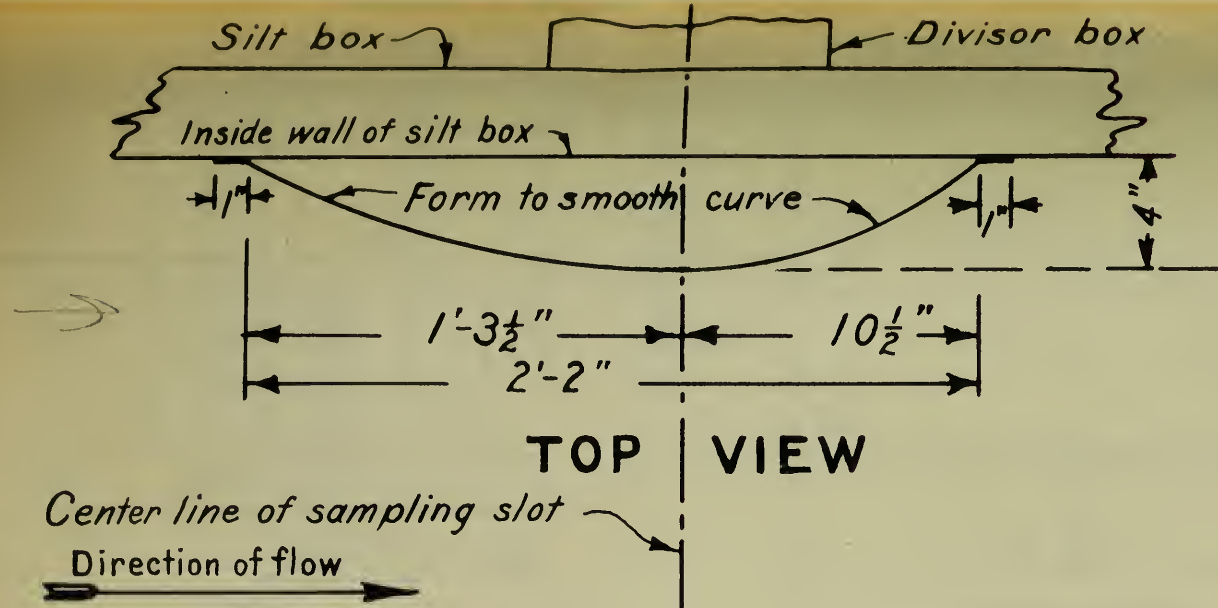
RAMSER SILT SAMPLER
AND
PARSHALL FLUME INSTALLATION

FIG. 8-B



BAFFLE FOR DIVISOR BOX
OF RAMSER SILT SAMPLER

FIG. 8-D



TOP VIEW

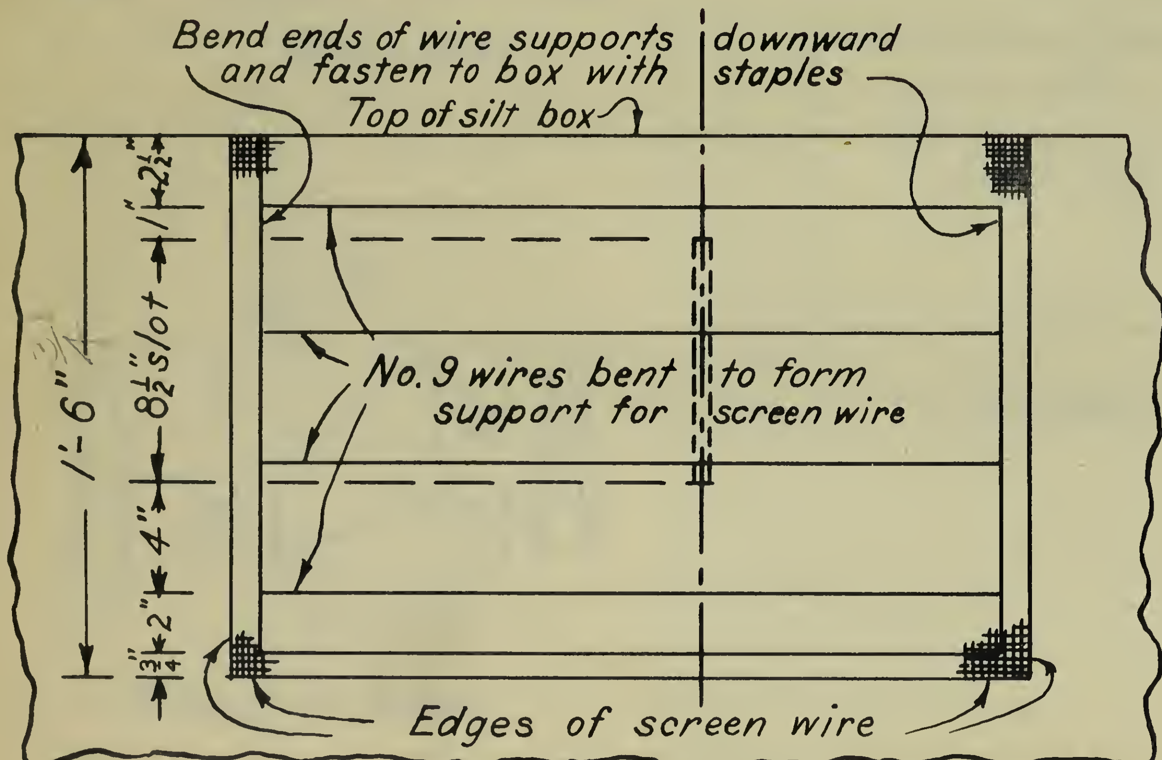
MATERIALS FOR ONE

1 piece 14 mesh galvanized screen wire, 24"x30"

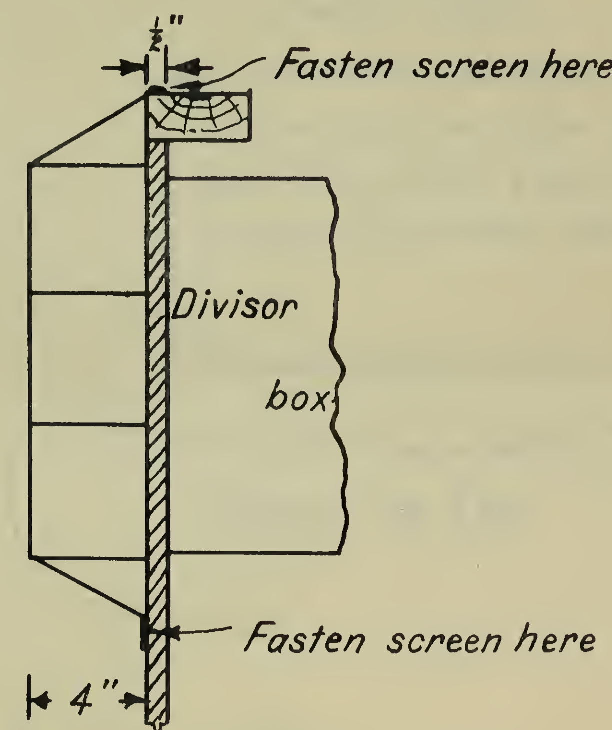
4 pieces #9 galvanized wire, 30" long

16 small staples for securing frame to silt box

3 doz. carpet tacks for fastening screen wire to box



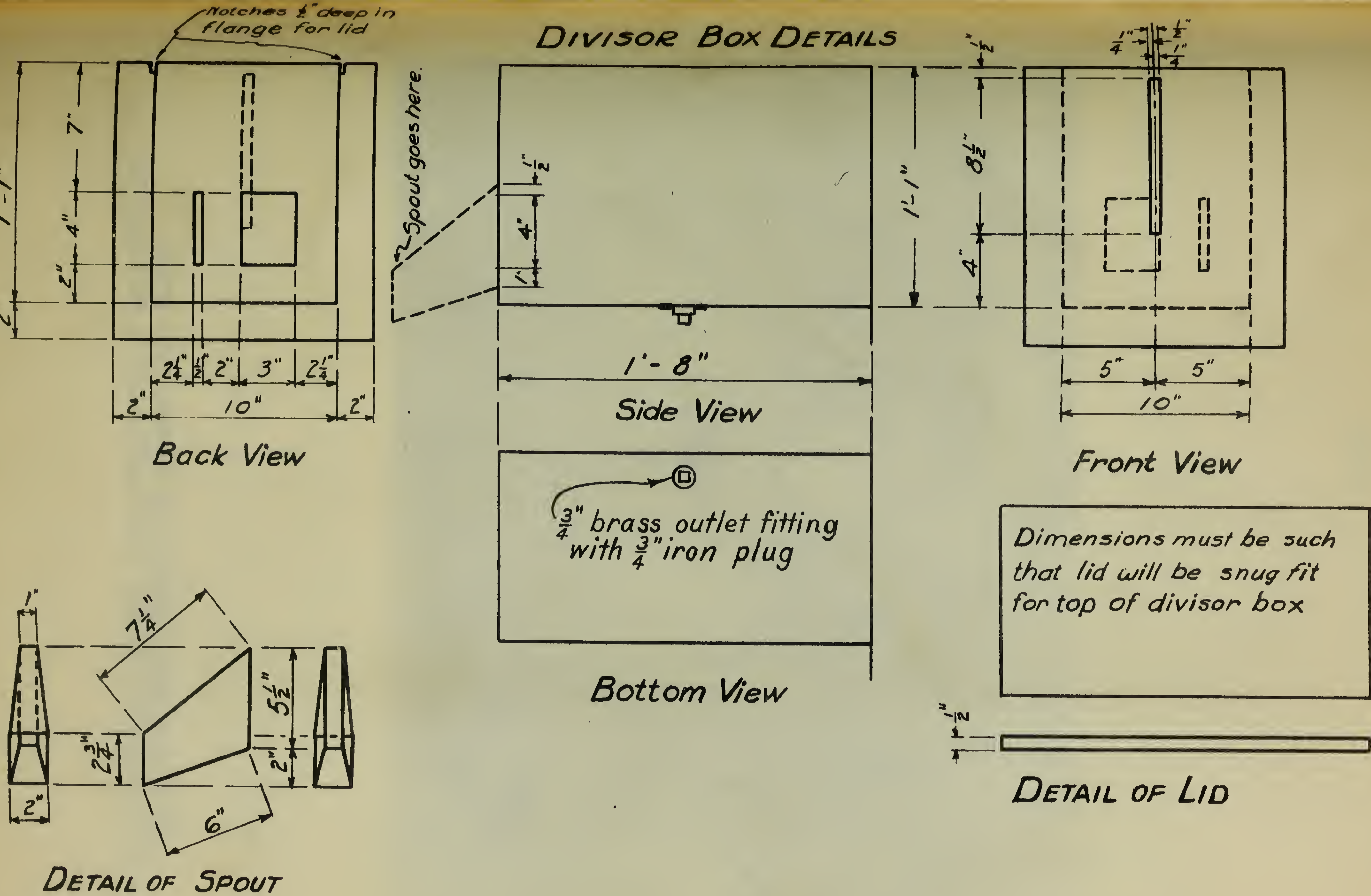
FRONT VIEW



SIDE VIEW

TRASH DEFLECTOR FOR RAMSER SILT SAMPLER

FIG. 8-E



DIVISOR BOX for Ramser silt sampling device

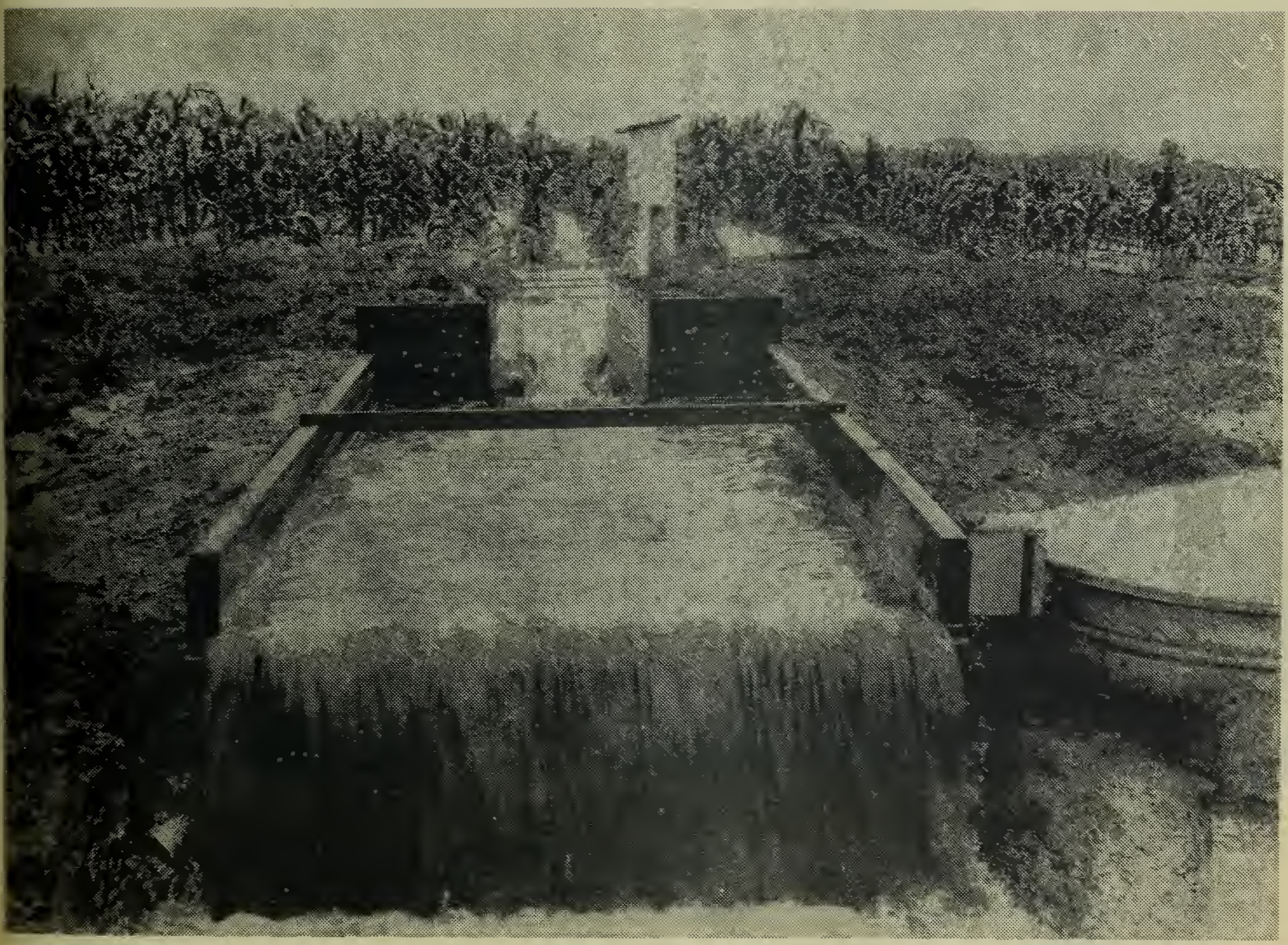
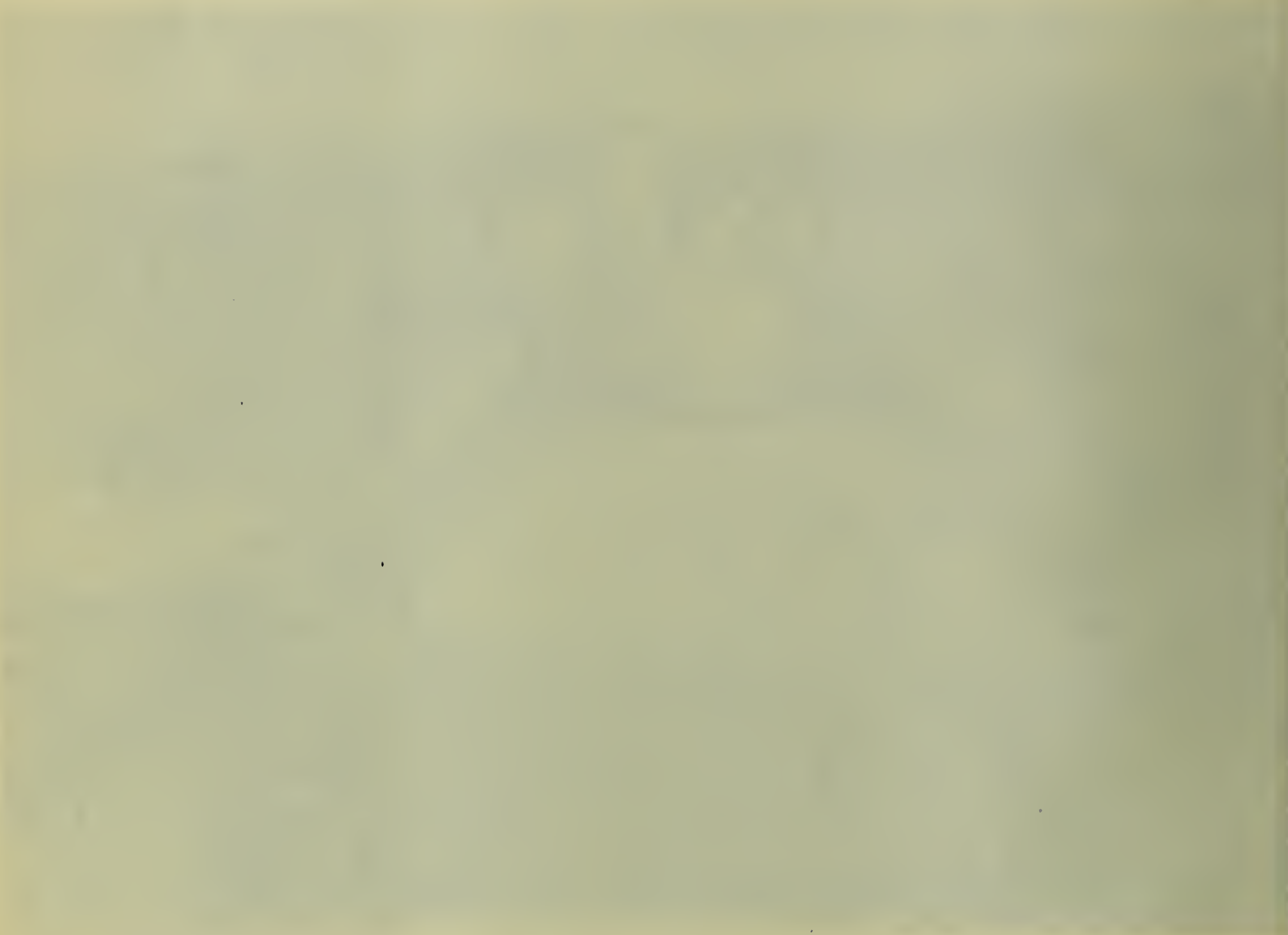


FIGURE 8-F

RAMSER SILT SAMPLER AND PARSHALL MEASURING FLUME
IN OPERATION AT THE GUTHRIE SOIL EROSION EXPERIMENT STATION



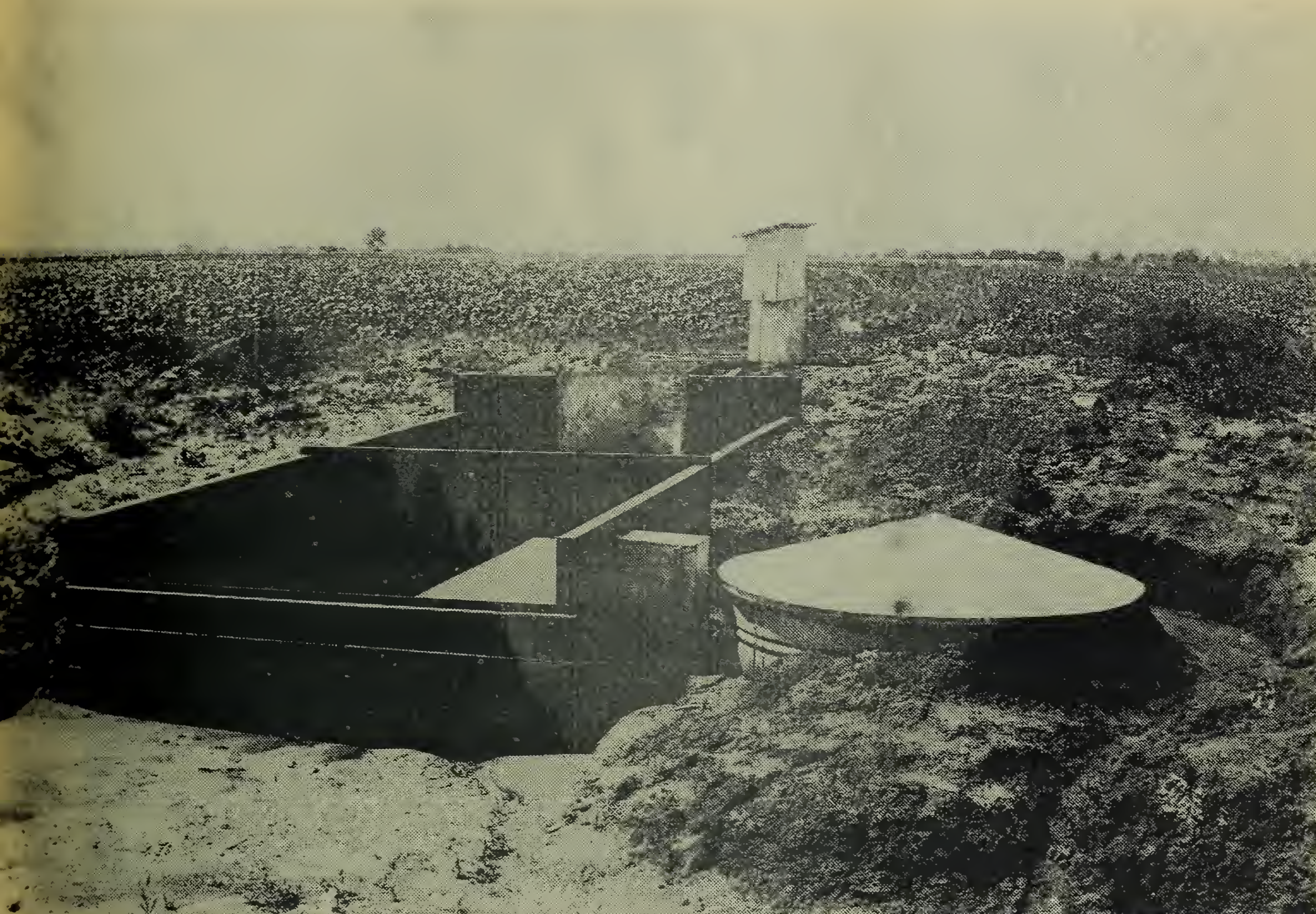


FIGURE 8-G

PARSHALL MEASURING FLUME, RECORDER SHELTER, SILT BOX, AND SILT SAMPLE STORAGE TANK

(Installed at the Guthrie Soil Erosion Experiment Station by the U. S. Bureau of Agr. Engineering)

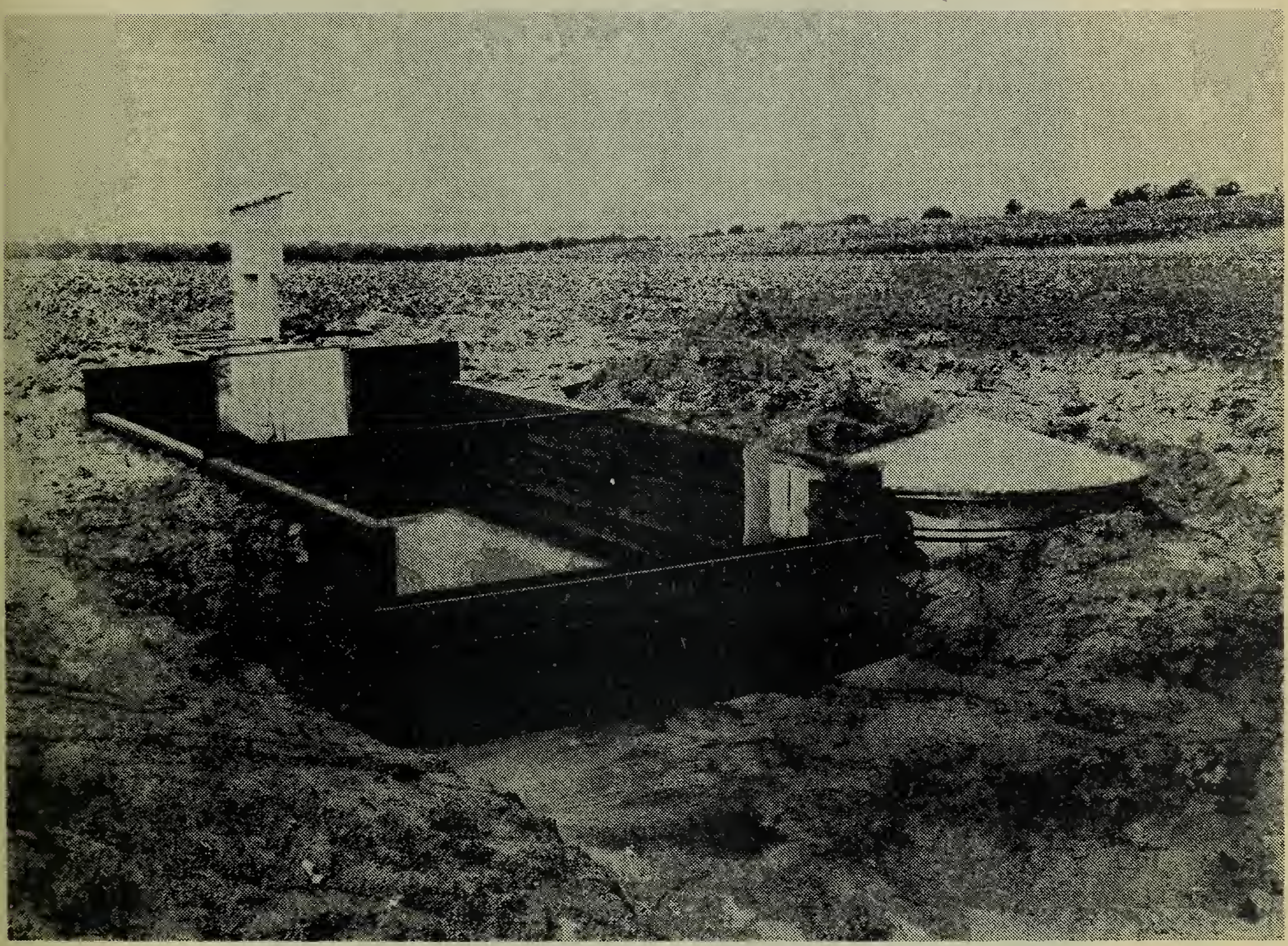


FIGURE 8-H

PARSHALL MEASURING FLUME, RECORDER SHELTER, SILT BOX, AND RAMSER SILT SAMPLING DEVICE.

(Installed at the Guthrie Soil Erosion Experiment Station by the U. S. Bureau of Agr. Engineering)

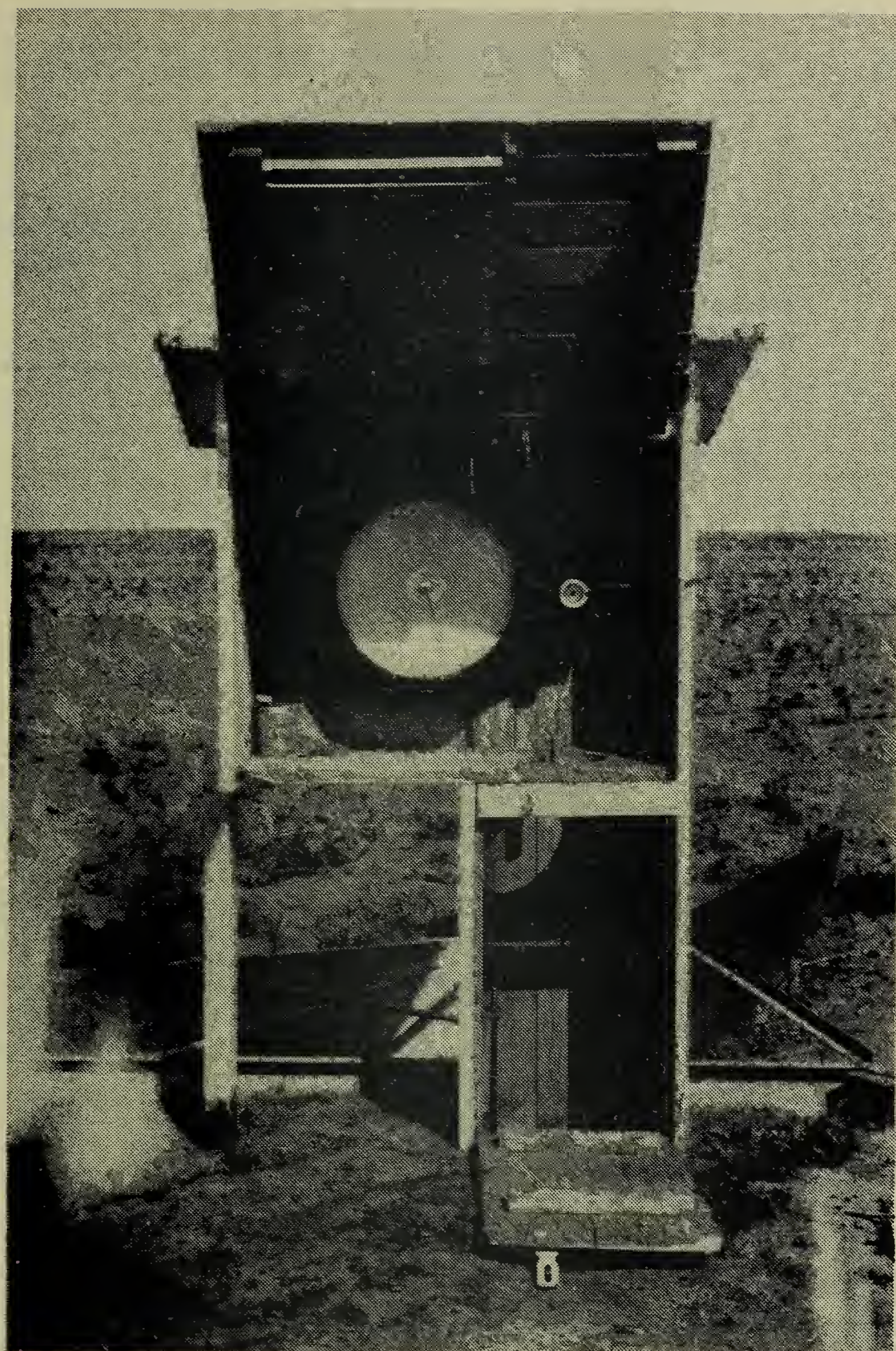
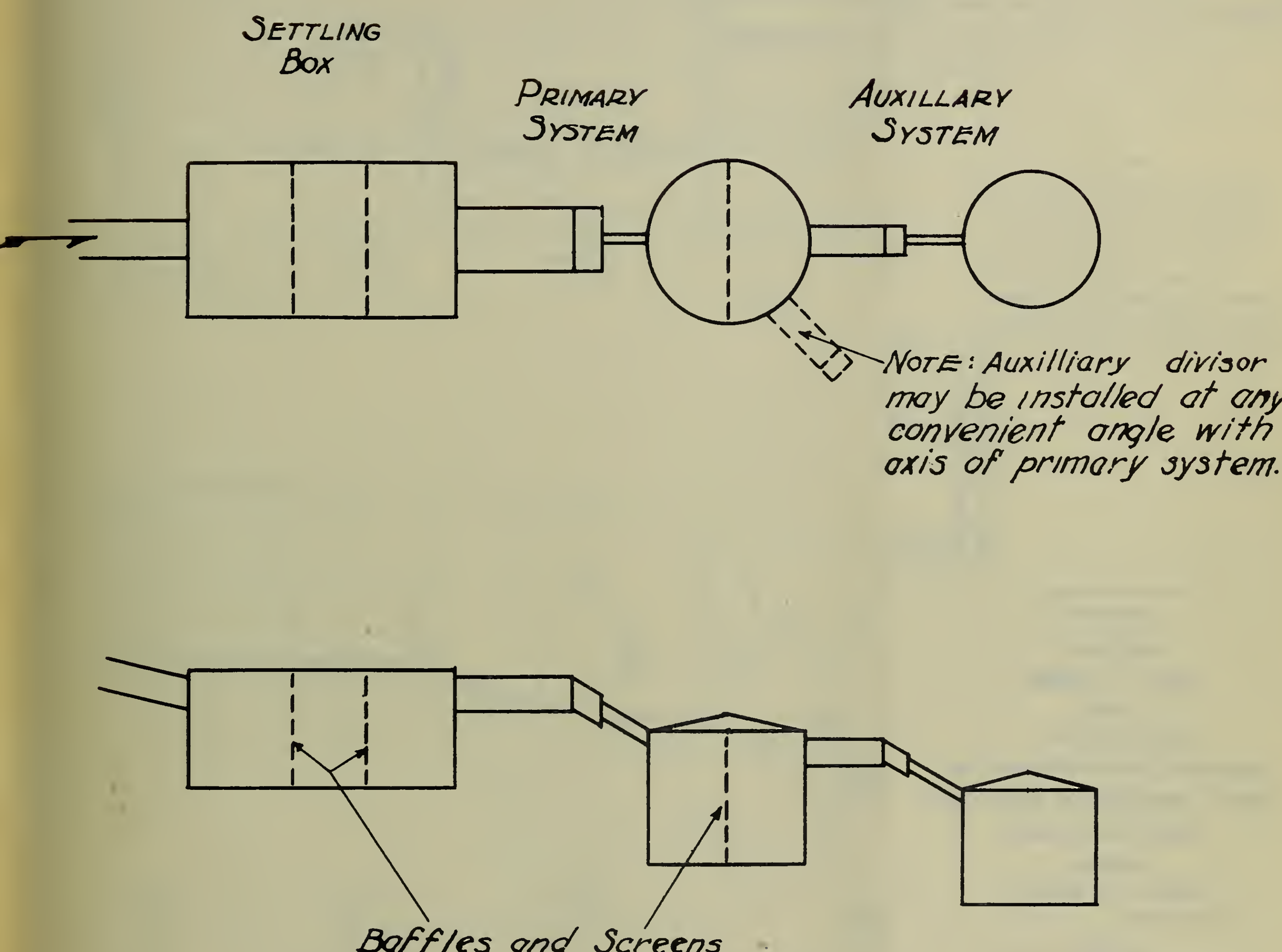
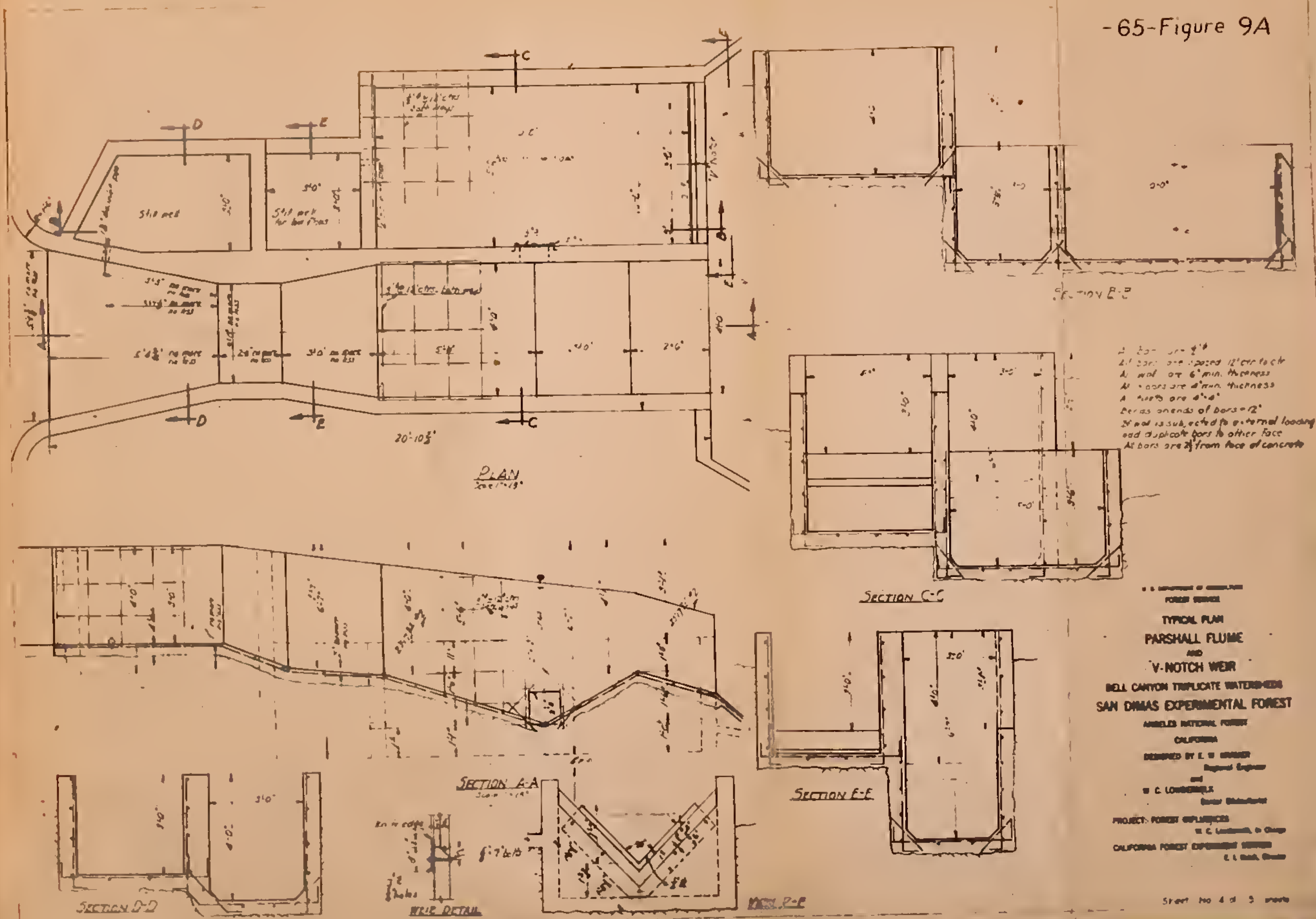


FIGURE 8-I
BRISTOL WATER LEVEL RECORDER
FOR PARSHALL MEASURING FLUME
(Installed at the Guthrie Soil Erosion Experiment Station by the Bureau of Agricultural Engineering)

Figure No. 8K



GEIB DIVISOR LAYOUT


PLAN
SECTION A-A
SECTION C-C
SECTION D-D
SECTION E-E
WEIR DETAIL
20'-10½"
Still well
Ends of bars 2½" from face of concrete
All bars are spaced 12" ctr to ctr
All walls are 6" min. thickness
All floors are 6" min. thickness
All footings are 4"×4"
Laps on ends of bars = 12"
If wall is subjected to external loading add duplicate bars to other face
All bars are 2½" from face of concrete
TYPICAL PLAN
PARSHALL FLUME
AND
V-NOTCH WEIR
BELL CANYON TRIPLICATE WATERSHEDS
SAN DIMAS EXPERIMENTAL FOREST
ANGELES NATIONAL FOREST
CALIFORNIA
DESIGNED BY
Regional Engineer
and
W. C. LOWDERMILK
PROJECT: FOREST INFLUENCES
CALIFORNIA FOREST EXPERIMENT STATION
Sheet No 4 of 5 sheets

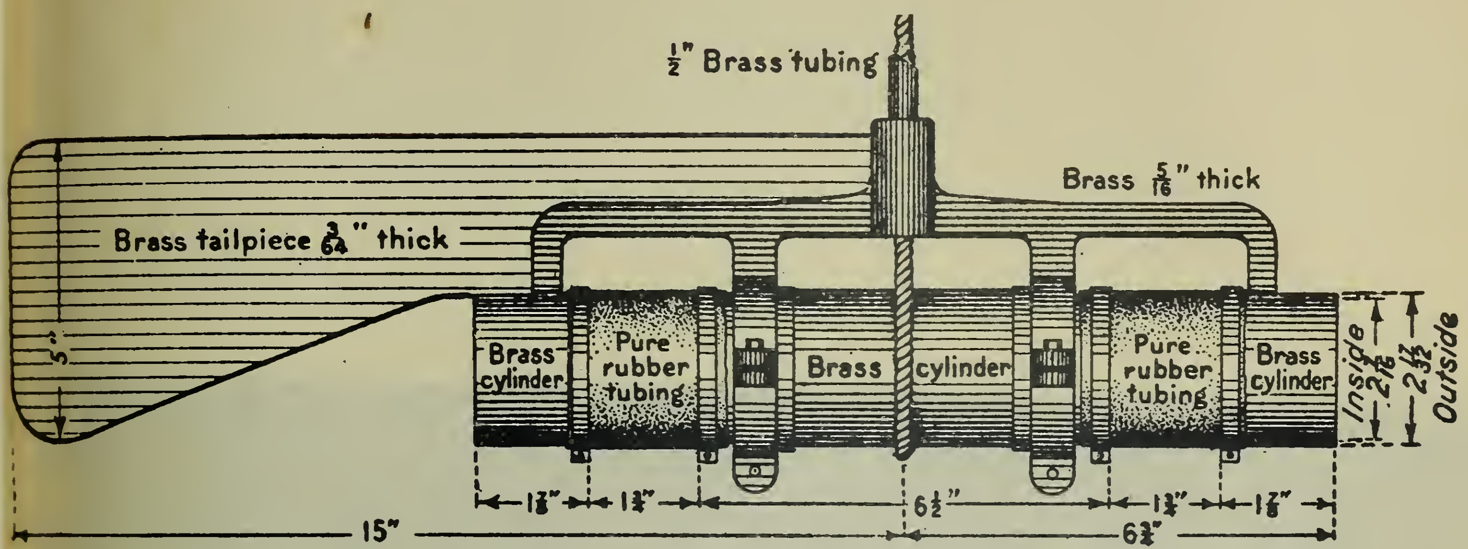


FIGURE 9-B

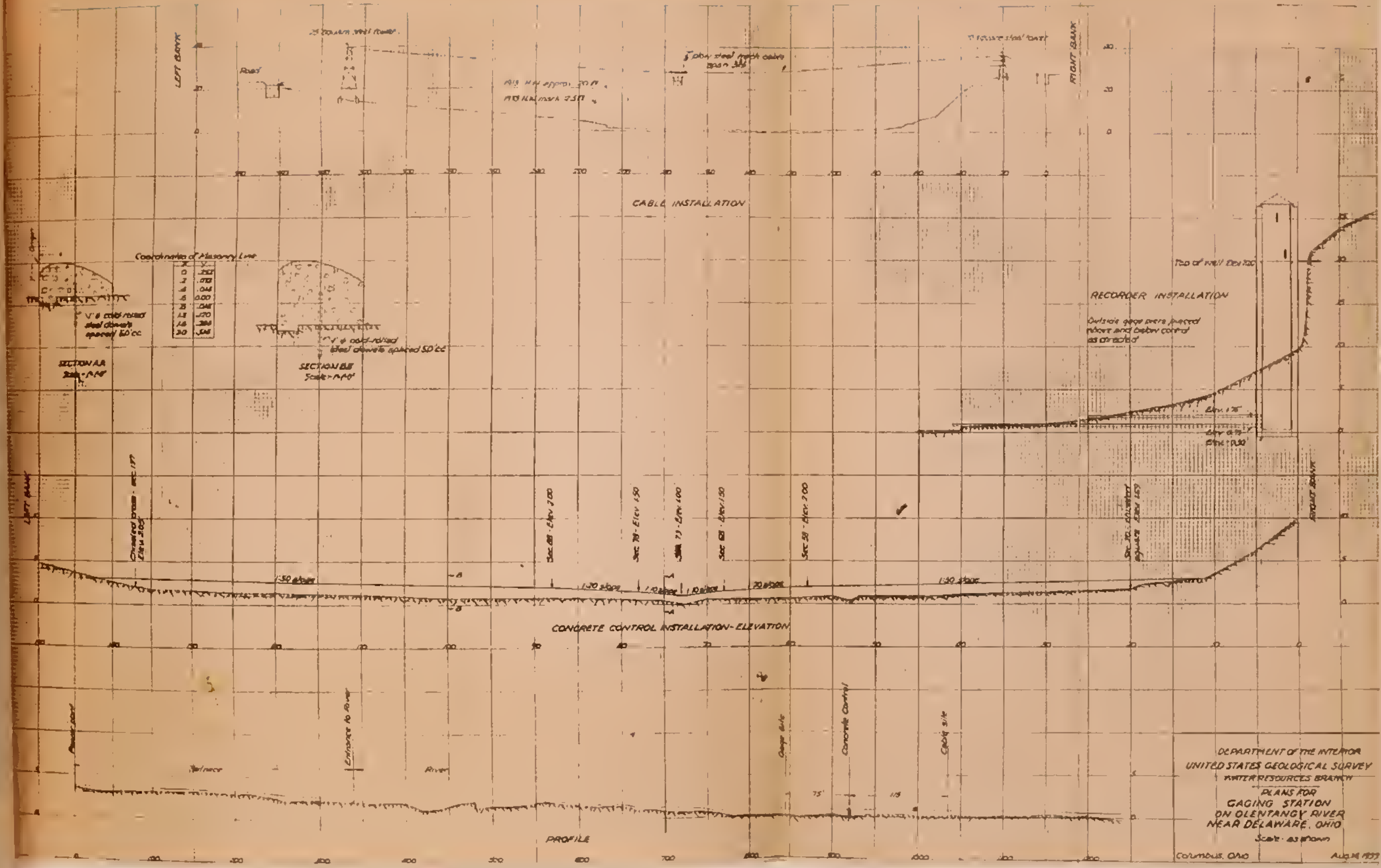
TAIT - BINCKLEY SILT SAMPLER

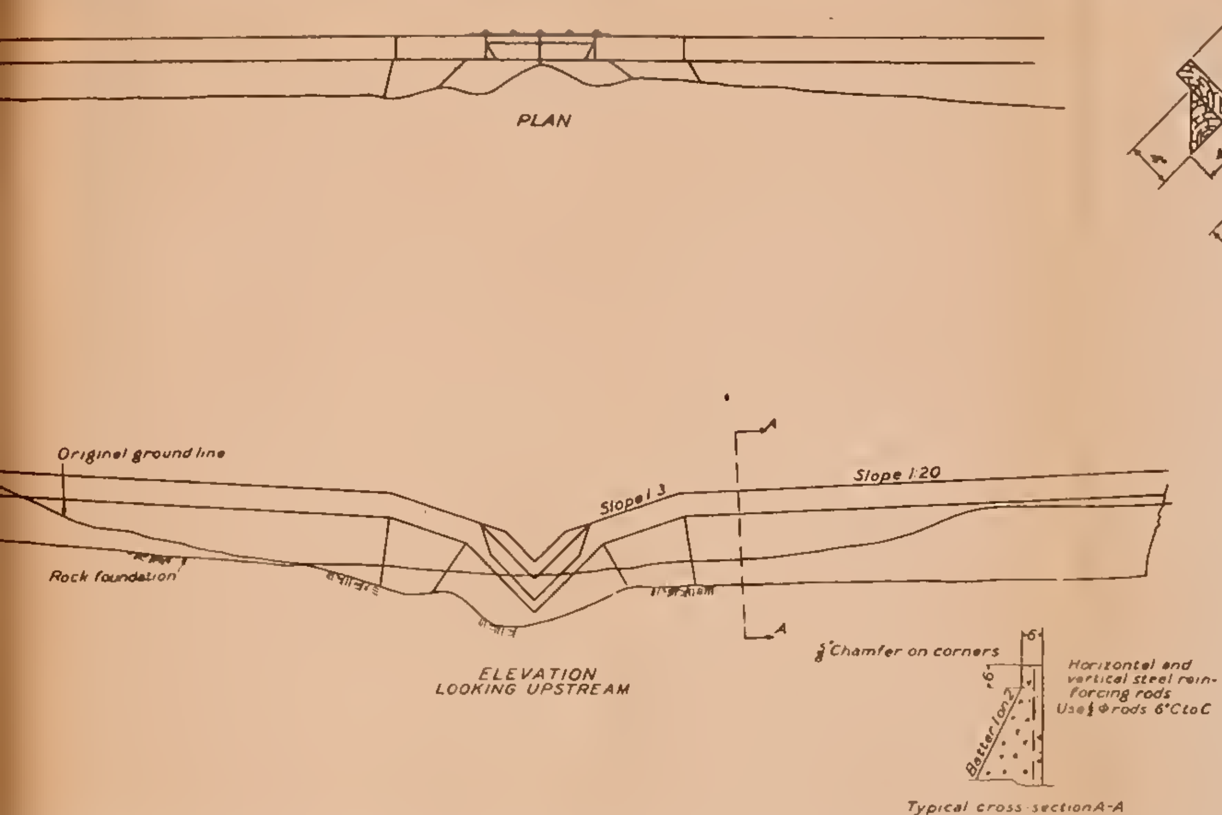
(Taken from U.S.D.A. Technical Bulletin No.67, page 12)

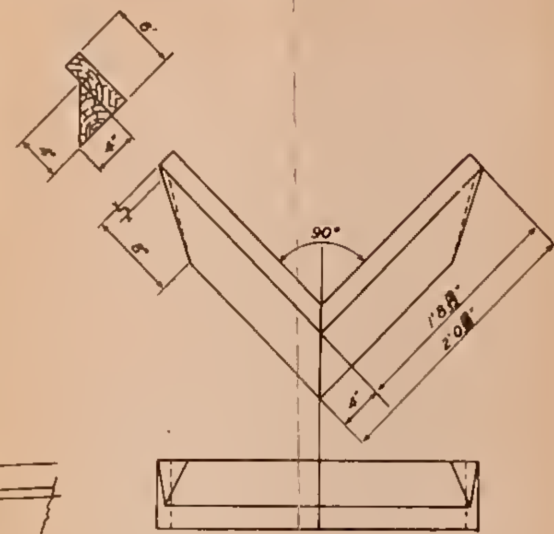
FIGURE 9-C

LARGE SIZE PARSHALL MEASURING FLUME
WITH AUXILIARY V NOTCH WEIR EQUIPPED WITH STAGE RECORDERS

(San Dimas Experimental Forest, U. S. Forest Service)


LEFT BANK
RIGHT BANK
CABLE INSTALLATION
Coordinates of Masonry Line
SECTION AA
SECTION BB
RECORDER INSTALLATION
Top of wall
CONCRETE CONTROL INSTALLATION-ELEVATION
1:30 slope
PROFILE
Terrace
River
Gage site
Concrete Control
Cable site
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES BRANCH
PLANS FOR
GAGING STATION
ON OLENTANGY RIVER
NEAR DELAWARE, OHIO
Scale - as shown
Columbus, Ohio





Sketch of form used in construction of concrete notch section

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

V-NOTCH CONTROL
SHACKHAM BROOK NEAR
TRUXTON, N.Y.

ALBANY, NEW YORK
AUGUST 24, 1933

A.W. HARRINGTON
DISTRICT ENGINEER

FIGURE 10-C

CREOSOTED TIMBER CONTROL WEIR FOR GAGING STATION

(Installed by the U. S. Geological Survey on the
Soil Conservation Service Project #9, Oklahoma

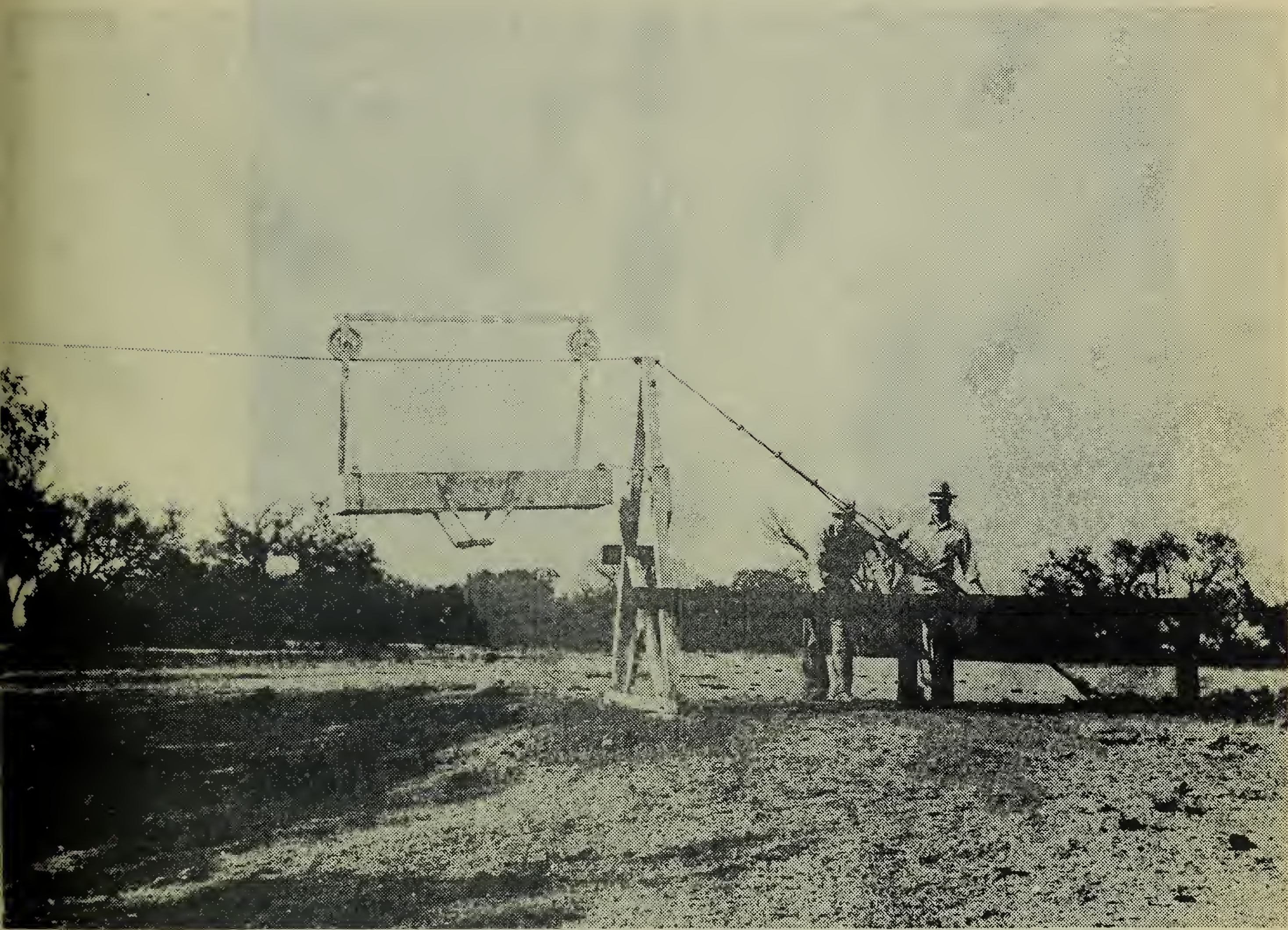


FIGURE 10-D.

CABLE CAR AND A BRACE FOR STREAM GAGING STATION

(Installed by the U. S. Geological Survey on the Soil Conservation Service Project #11, Kansas)

FIGURE 10-E

CONCRETE RECORDER SHELTER HOUSE
FOR STREAM GAGING STATION

(Installed by the U. S. Geological Survey
on Soil Conservation Project #2,Missouri)

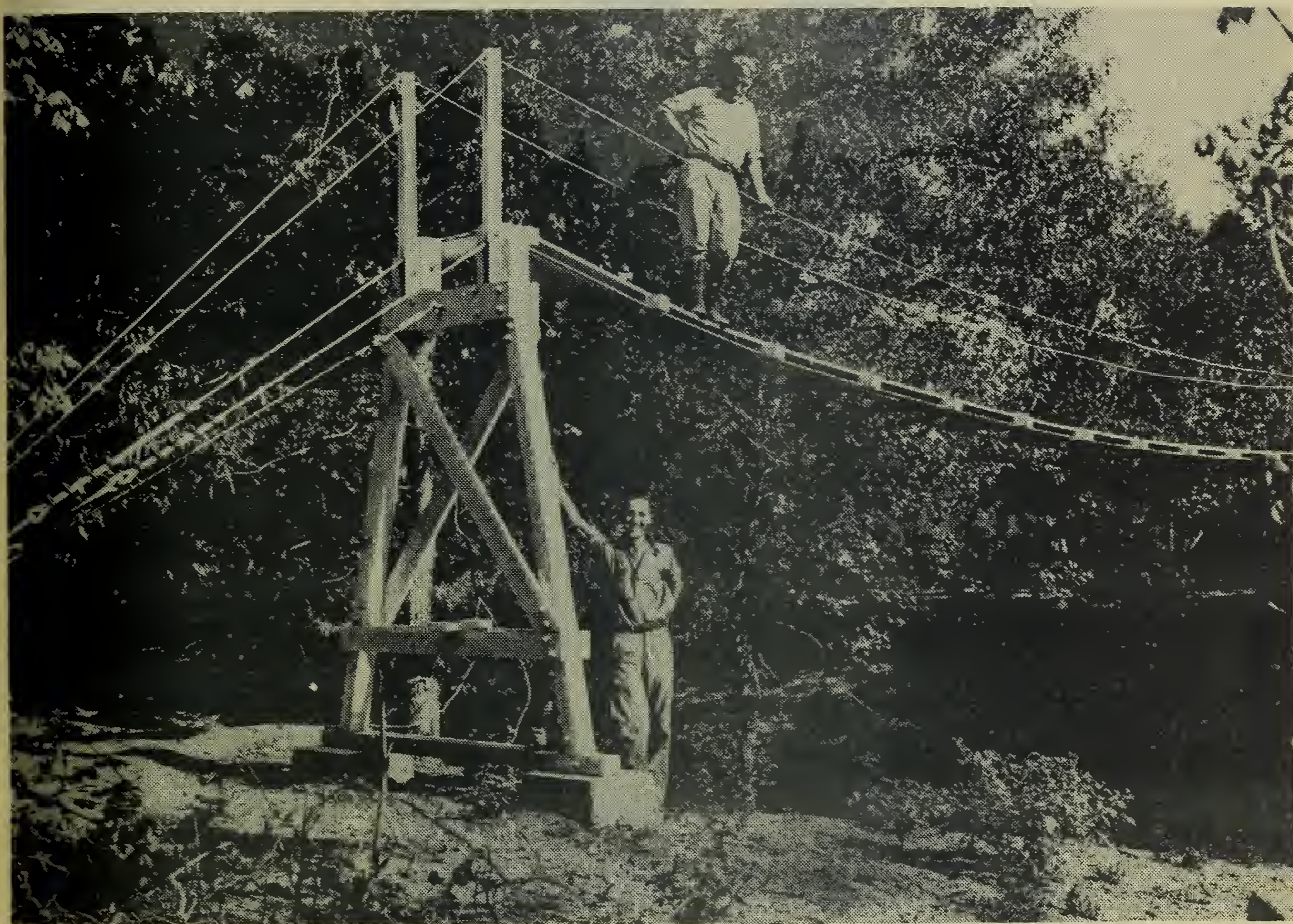
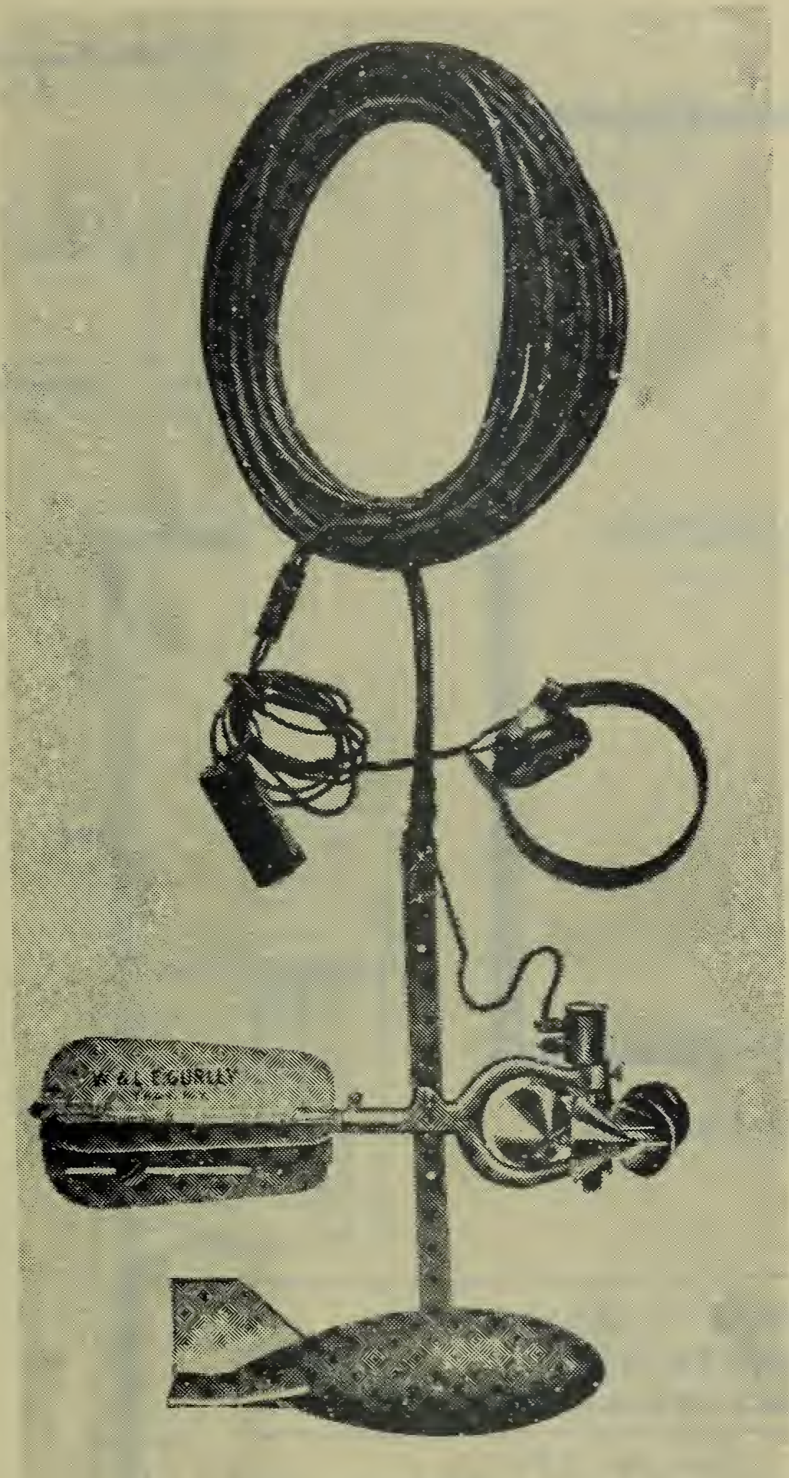


FIGURE 10-F

SUSPENSION BRIDGE FOR GAGING STATION

(Installed by U. S. Geological Survey on the Soil Conservation Service Project #4, Texas)

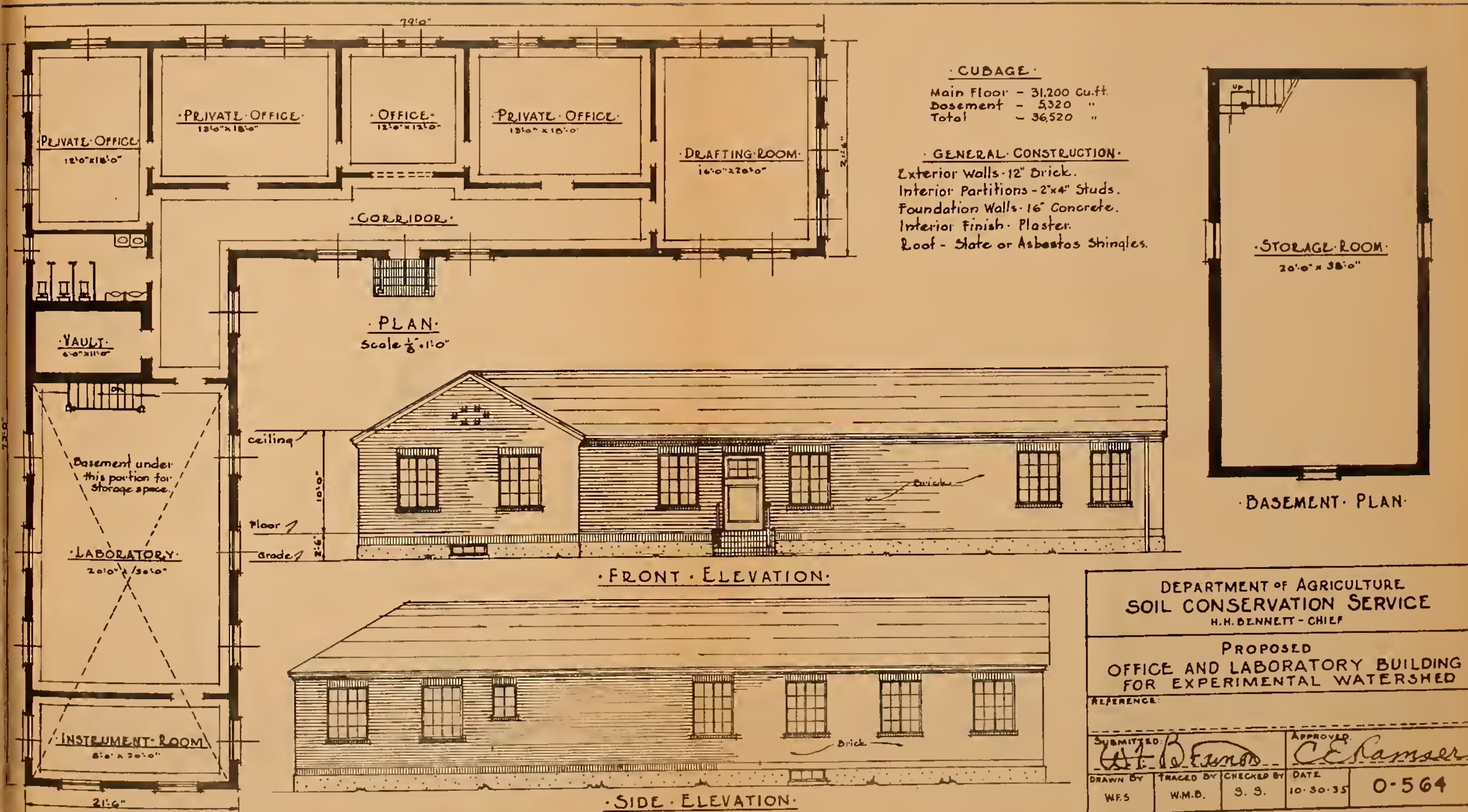


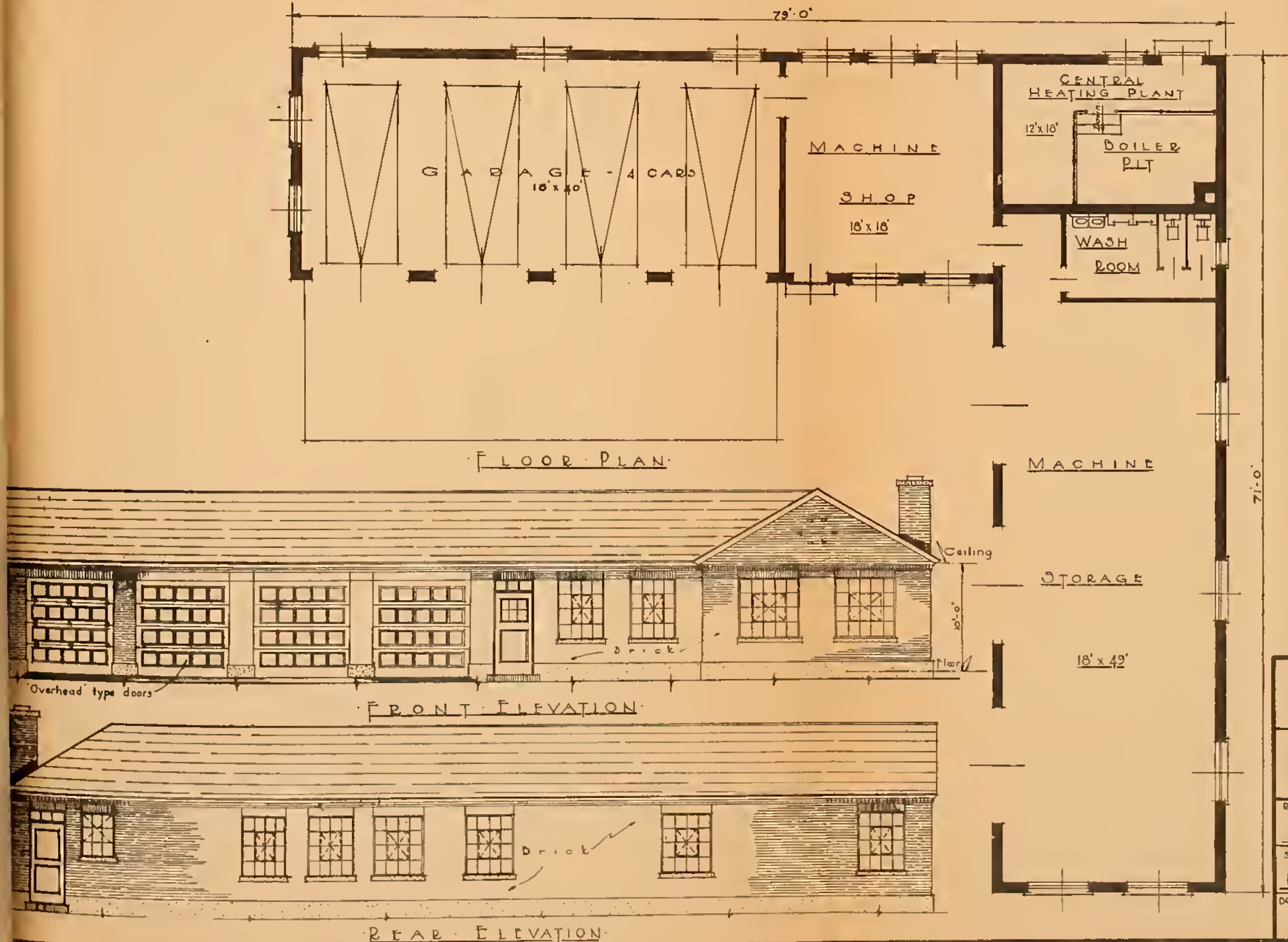
No. 622-A

FIGURE 10-G

SMALL "PRICE" CURRENT METER

(Taken from Gurley
Bulletin No. 700)


79'0"
PRIVATE OFFICE 12'0"x18'0"
PRIVATE OFFICE 13'0"x18'0"
OFFICE 12'0"x12'0"
PRIVATE OFFICE 13'0"x18'0"
DRAFTING ROOM 16'0"x20'0"
CORRIDOR
VAULT
Basement under this portion for storage space.
LABORATORY 20'0"x30'0"
INSTRUMENT ROOM 8'0"x20'0"
21'6"
PLAN
Scale 1/8"=1'0"
CUBAGE
Main Floor - 31,200 Cu.ft.
Basement - 5,320 "
Total - 36,520 "
GENERAL CONSTRUCTION
Exterior Walls - 12" Brick.
Interior Partitions - 2"x4" Studs.
Foundation Walls - 16" Concrete.
Interior Finish - Plaster.
Roof - Slate or Asbestos Shingles.
UP
STORAGE ROOM 20'0"x38'0"
BASEMENT PLAN
ceiling
Floor
Grade
10'0"
2'6"
Brick
FRONT ELEVATION
Brick
SIDE ELEVATION
DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. BENNETT - CHIEF
PROPOSED
OFFICE AND LABORATORY BUILDING
FOR EXPERIMENTAL WATERSHED
REFERENCE:
SUBMITTED:
APPROVED: C E Ramser
DRAWN BY W.F.S
TRACED BY W.M.B.
CHECKED BY S. S.
DATE 10-30-35
0-564



·GENERAL·CONSTRUCTION·

Exterior walls · 12" Brick
Foundations 16" Concrete
Interior walls 4" T.C.
Boiler room walls - 8" Brick
Machine Shop & Wash Room - plaster finish
Wash Room - Tile wainscot
Sash - Pivot Steel - industrial type
Roof · Slate or Asbestos shingles

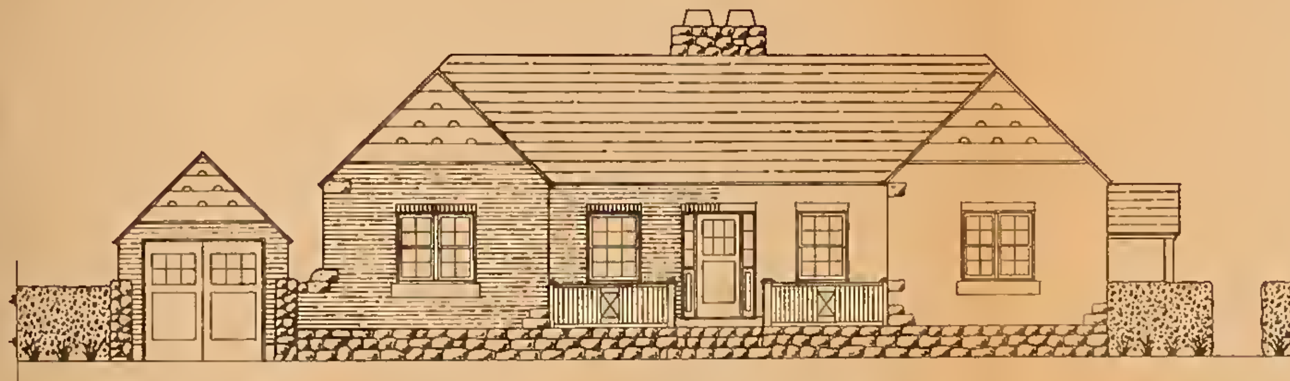
Cube 23,352 cu.ft.

Scale 1/8" = 1 Ft.

DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. BENNETT, CHIEF.

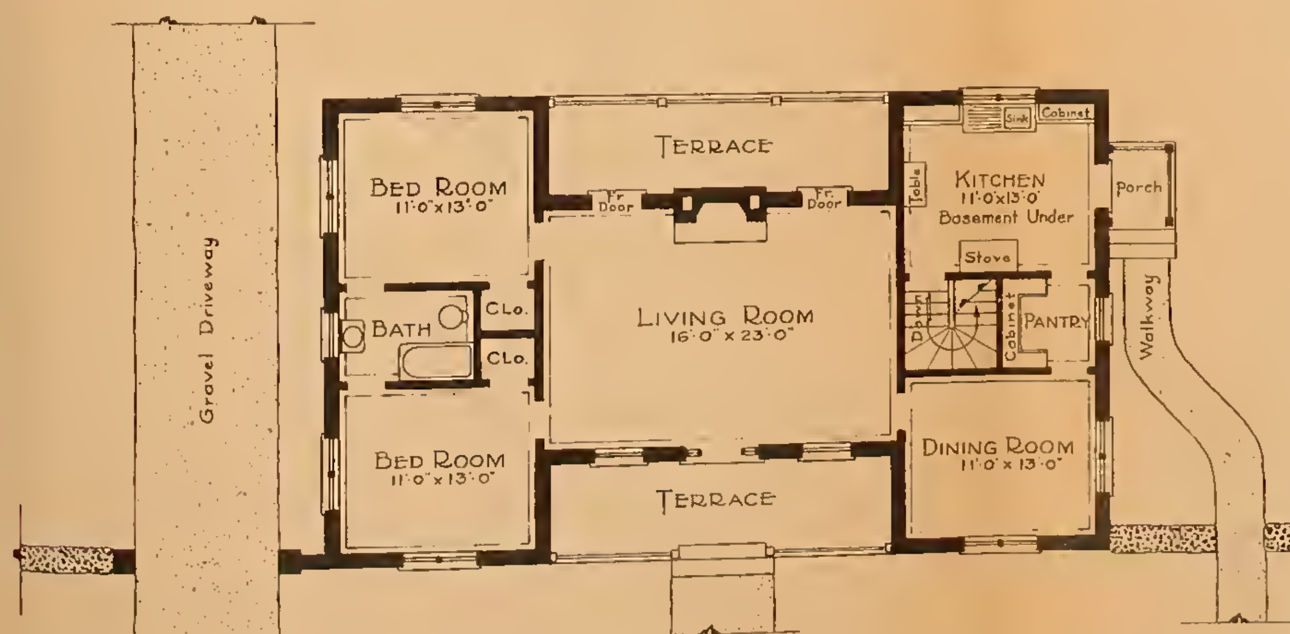
PROPOSED
GARAGE & WORK BUILDING
FOR EXPERIMENTAL WATERSHED

REFERENCE:				
SUBMITTED:		APPROVED:		
DRAWN W.F.S.	TRACED: S.S.	CHECKED: W.M.B.	DATE 10-30-35	0-565



Front Elevation

Side Elevation



Floor Plan
Scale - 1/8" = 1'-0"

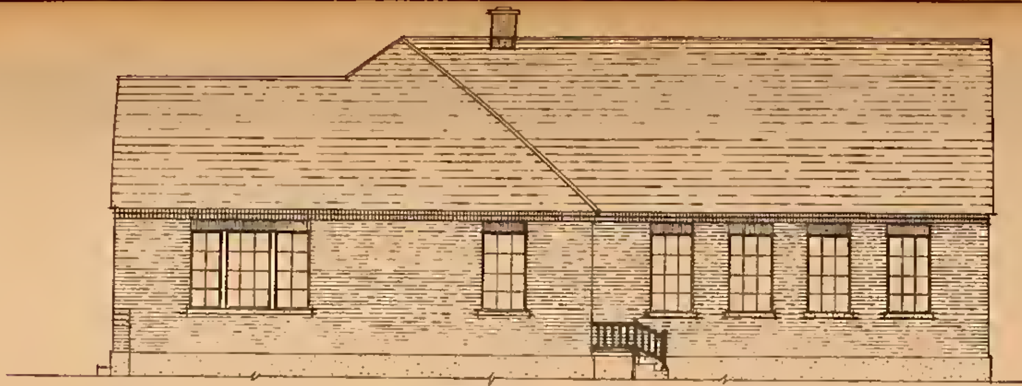
CUBE

Main Floor	12,000	Cu Ft.
Basement	1,700	" "
Attic	7,500	" "
Total	21,200	" "

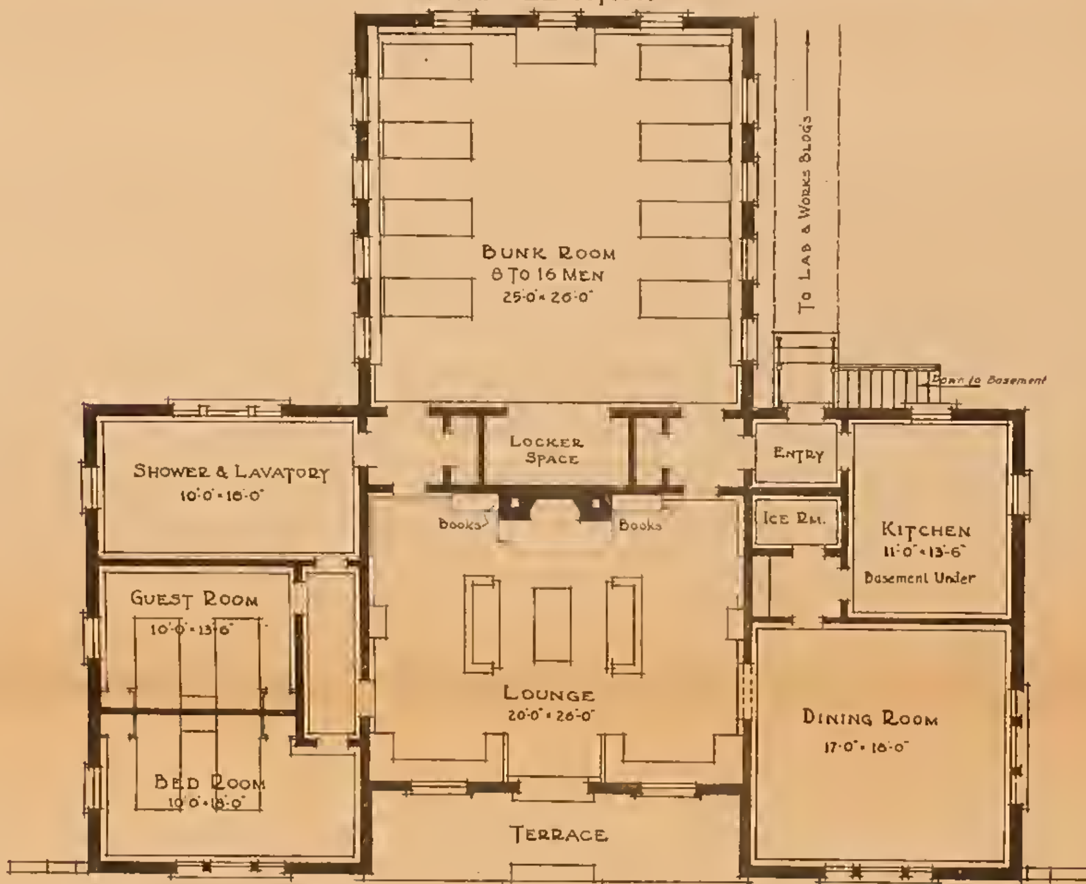
DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. BENNETT, CHIEF

HEADQUARTERS
RESIDENCE
EXPERIMENTAL WATERSHED
SCHEME - 9

Submitted	Approved			
W. J. Beane	C. E. Ramser			
Drawn by W.J.W.	Traced by J.T.C.	Checked by W.J.W.	Date	0-591



SIDE ELEVATION



FLOOR PLAN

FRONT ELEVATION

SCALE 1/8" = 1'-0"

CUBE

MAIN FLOOR	35,490	CU. FT.
BASEMENT	1,760	" "
TOTAL	37,250	" "

DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
H. H. BENNETT, CHIEF

HEADQUARTERS
STAFF HOUSE
EXPERIMENTAL WATERSHED
SCHEME 1-B

SUBMITTED	APPROVED		
W. L. Brand[?]	C. E. Ramser		
DRAWN BY S.D.M.	TRACED BY W.F.S.	CHECKED BY W.J.W.	DATE

0-592

11-D

78

ORGANIZATION CHART FOR THE SECTION OF WATERSHED AND HYDROLOGIC STUDIES

BASED ON APPROVED BUDGET

APPROVED BY:

______________ DATE ______

______________ DATE ______

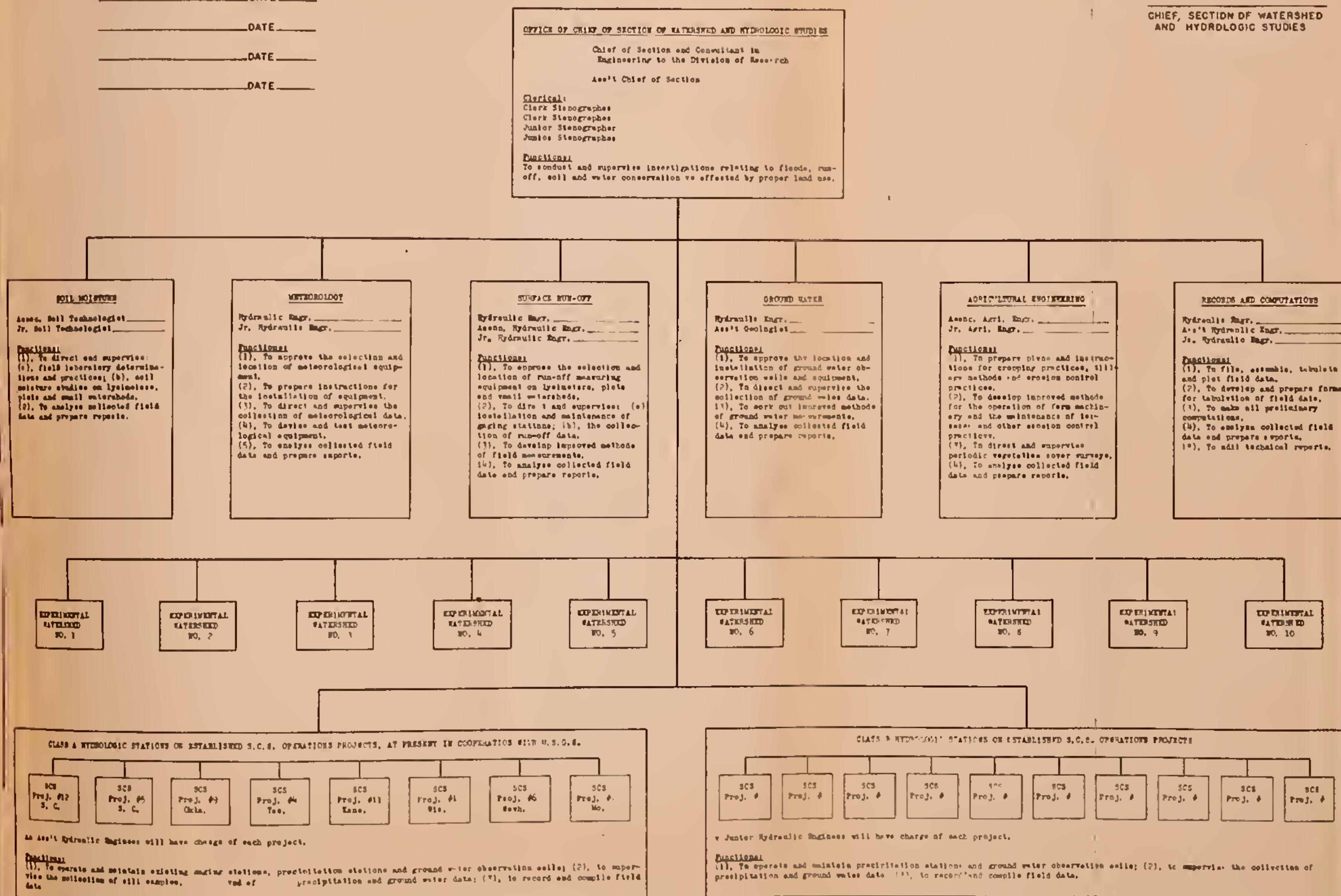
______________ DATE ______

______________ DATE ______

SUBMITTED BY:

____

CHIEF, SECTION OF WATERSHED AND HYDROLOGIC STUDIES



Note: Experimental Watershed No. 1 has been selected and is located on the watershed of the Muskingum River, Ohio
" " No. 2 to be selected within the watershed of the Greene River, " ".
" " to 10 are to be located in various representative regions of the United States.
See organization chart for one Experimental Watershed.

ORGANIZATION CHART FOR ONE EXPERIMENTAL WATERSHED

BASED ON APPROVED BUDGET

APPROVED BY:

________________ DATE ________

________________ DATE ________

________________ DATE ________

________________ DATE ________

SUBMITTED BY:

____

CHIEF SECTION OF WATERSHED AND HYDROLOGIC STUDIES

FIELD HEADQUARTERS OFFICE

Superintendent ________
Clerk Stenographer ________
Junior Stenographer ________
Junior Stenographer ________

Functions:
(1), To supervise and direct work of technical personnel on Watershed; (2), to negotiate with cooperators; (3), to arrange for necessary leases and contracts; (4), to have charge of administrative and fiscal matters.

WOODLOT STUDIES

Ass't Forester ________

Functions:
(1), To prepare plans for and direct woodlot management; (2), to prepare instructions for vegetal and litter surveys; (3), to have charge of this work on 3 watersheds with field headquarters.

SOIL MOISTURE STUDIES

Assoc. Soil Technologist ________
Ass't Soil Technologist ________

Functions:
(1), To make laboratory determinations of soil moisture on lysimeters, plots and watersheds; (2), to determine silt content of run-off water, to make soil and erosion surveys; (3), to make field observations, to record data; (4), to make computations and prepare reports.

RUN-OFF STUDIES

Assoc. Hydraulic Engineer ________
Ass't Engineering Aide ________
Ass't Engineering Aide ________

Functions:
(1), To install and maintain run-off measuring equipment on lysimeters, plots and small watersheds; (2), to install, rate, and maintain stream gaging stations and equipment; (3), to collect silt samples and field records; (4), to record data, make computations and prepare reports on Run-off, Meteorological and Ground Water Investigations.

AGRICULTURAL ENGINEERING

Assoc. Agricultural Engineer ________
Ass't Engineering Aide ________
Farm Foreman ________
Skilled Mechanic ________

Functions:
(1), To superintend farm operations; (2), to lay out and superintend the construction of terraces and erosion control practices; (3), to keep records of the condition of cover on small watersheds; (4), to record data and prepare reports.

METEOROLOGICAL OBSERVATIONS

Ass't Hydraulic Engineer ________
Ass't Engineering Aide ________

Functions:
(1), To install and maintain meteorological equipment; (2), to make meteorological observations and keep records; (3), to supervise the collection of precipitation and temperature data; (4), to record data and make computations.

GROUND WATER OBSERVATIONS

Ass't Engineering Aide ________

Functions:
(1), To install and maintain ground water observation wells; (2), to make measurements and record ground water and fluctuations.

APPENDIX I

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

H. H. Bennett, Chief
W. C. Lowdermilk, Associate Chief and Acting
Head of Division of Research

PROVISIONAL WORKING PLAN
for
WATERSHED STUDIES
Relating to
WATER CONSERVATION, FLOOD CONTROL, AND RUN-OFF
AS INFLUENCED BY LAND USE AND METHODS OF EROSION CONTROL
To be carried on in
TYPICAL AGRICULTURAL REGIONS OF THE UNITED STATES

by

C. E. Ramser
In Charge, Section of Watershed and Hydrologic Studies
and
D. B. Krimgold
Associate Hydraulic Engineer

A P P E N D I X I

"PROVISIONAL PLAN"

Table of Contents

I. PROJECT

Watershed studies relating to water conservation, water supply, flood control and run-off as affected by land use and methods of erosion control.

II. LOCATION

The watersheds to be studied will be located so as to be representative of typical regions of the United States. Sixteen tentative locations are indicated on an attached map, Fig. II-A. Of these, ten will be selected in the course of a map study to be made in the office. The final locations will be selected after a thorough field reconnaissance. In locating the watersheds the following factors will be considered: nature and extent of soil erosion, soil type, land use, crops, topography, climatology, physiography and geology; these factors being fairly uniform over each watershed. Other requirements with regard to the location of watersheds are:

(A). Two comparable watersheds adjacent if possible in each region of about 5,000 acres each, one to be the medium for erosion control practices and the other to remain essentially in its original state to serve as an integrator of climatic factors.

(B). Each major watershed should be made up of a number of smaller tributary watersheds suitable for experimental purposes. The major and tributary watersheds should be such that the entire flow from each can be kept under continuous observation and suitable sites should be available for measuring the stream flow and collecting silt samples. Also, suitable gaging station sites should be available for a number of watersheds ranging in size from the smallest tributary to the major watershed.

(C). The watersheds should contain land suitable for satisfactory erosion control experiments which will require 15 to 25 small watersheds of 5 to 15 acres preferably in one body of land.

(D). The watersheds should be located where the continuity of the experiment can be reasonably assured. This will likely require the outright purchase or long time lease of land where intensive experiments are located and actual control of farming operations is imperative as on the smallest watersheds.

(E). The watersheds should preferably be located where there is no diversion of water.

(F). Other factors that will determine the desirability of an area are:

(1). Accessibility by all-weather road systems.
(2). Communication facilities.
(3). Proximity to railroad.
(4). Power and light facilities.

III. OBJECT

(A). To determine the effect of land use and erosion control practices upon the conservation of water for crops and water supply and upon the control of floods.

(B). To determine the effect under (A) for small and large areas and to trace variations in this effect from the smallest plot and lysimeters through a series of intermediate watersheds to the largest watershed on the project.

(C). To determine the rates and amounts of run-off for precipitation of different amounts and intensities for watersheds of different configuration, size, shape, soil, topography, cover, underground conditions, land use, and erosion control practices.

IV. REASONS FOR STUDY

There are many practical reasons justifying the need for these studies all of which involve substantial financial benefits to the country. Some of these reasons are discussed below:

(A). Conservation of Water

(1). The experiences particularly in the semi-humid region of the country this year indicate the need of agricultural and land use practices to conserve the moisture for crops. Vegetative tillage and other methods of controlling erosion tend to conserve the moisture for crops so that information indicating the effectiveness of these methods is needed to substantiate the adoption of these methods in a nation-wide water conservation program.

(2). A knowledge of the effect of land use and erosion control practices upon both surface and underground water supply for municipal, irrigation, and other uses is important in a program designed to work out the proper relation between such uses which may in some cases be more or less conflicting. For instance, surface water supplies for cities often command first

consideration which demands that the watershed yielding the supply receive treatment conducive to the maximum yield consistent with land use. On the other hand, the replenishment of the underground supply by proper treatment of the watershed conducive to the maximum amount of percolation may make available an increased supply from wells for irrigation purposes, which would, no doubt, have resulted in untold benefits to the drouth stricken and wind erosion areas during the past year.

(3). The effect upon the low water flow in streams for navigation and water power purposes resulting from treatment of watersheds to increase percolation and thereby the amount of water that reaches the streams, deserves considerable study since immense benefits would result to both navigation and water power projects in a better regulated and more uniform stream flow.

(B). Flood Control

(1). One of the primary objects of flood control from an agricultural standpoint is to prevent the overflow of rich bottom lands and prevent injury or complete damage to crops. Often floods result in the loss of lives and destruction of valuable city property. The extent to which the destructiveness of such floods can be ameliorated by proper treatment of the watershed is a subject worthy of a careful and comprehensive study.

(2). Floods are usually attended by the movement of large amounts of silt in the flood waters. The final disposition of this silt is often inimical to the best interests of landowners and municipalities.

(a). Heavy coarse silt is often deposited over rich bottom lands, often rendering the land ~~either~~ permanently unproductive where the deposit is deep. Even where the deposit is shallow the productivity of the land is often appreciably reduced and the difficulty and cost of tilling the soil is increased. Numerous examples of serious damage to bottom lands in this way are quite common throughout the country.

(b). Silt is often deposited in the channels of navigable streams, natural channels or dredged ditches. These channels must be cleaned out periodically at great expense in order to prevent

floods and insure navigability. As an example, a large dredged outlet ditch of a drainage district in the Missouri River bottoms in eastern Nebraska was nearly filled in one season with sediment contributed by 18 small tributary upland watersheds. This filling could no doubt have been greatly reduced or practically eliminated by the proper treatment of the land on these watersheds.

(c). The collection of this silt in reservoirs for municipal, irrigation, or other uses, built at great expense, reduce their needed capacity, often resulting in a shortage of water during critical periods of the year, and always resulting in a financial loss to the community. Examples of reservoirs that have lost a considerable or even a major part of their capacity throughout the country are too numerous to mention. Possibly one of the most glaring illustrations is that of the Austin Dam in Texas that was nearly filled with sediment during a period of about fifteen years.

It hardly seems necessary to comment upon the great need to study the effectiveness of methods of treating watersheds that will result in a minimum yield of silt and thereby obviate the costly difficulties described above.

(C). <u>Rates and Amounts of Run-off from Agricultural Areas.</u>

Information relating to rates and amounts of run-off from a watershed is sorely needed in the economic design of engineering structures. If such structures are inadequate to handle the run-off from a watershed, failure will follow resulting in damage to or total loss of the structure. On the other hand, if such structures have a much greater capacity than is necessary to take care of the run-off, then a financial burden is imposed corresponding to the cost of the surplus capacity. From this it is obvious that comprehensive studies are justified to study run-off from watersheds in order that a financial saving may be effected through the most economic design of engineering structures.

This information is needed for the design of notches for check dams; spillways and drop-inlet culverts for soil-saving dams; channels and outlet ditches for terraces; and diversion ditches required in erosion control projects.

V. THE PROBLEM

(A). Statement

The problem consists of a detailed and comprehensive study of the action of water from the time it reaches the ground surface as precipitation until it leaves the watershed as surface or underground flow, which will include studies of precipitation, percolation, evaporation, transpiration, surface and underground storage, and rate of movement over the ground surface and through stream channels.

(B). Factors

A more detailed outline of the factors to be considered and analyzed in the ultimate solution of the problem in their relation to run-off, water conservation, and flood control is given below:

(1). Physical characteristics of watersheds.

(a). Soil and subsoil

1. Texture
2. Structure
3. Composition
4. Degree of saturation

(b). Topography

1. Degree and length of slopes
2. Uniformity and regularity of ground surface across and along slopes.

(c). Physiography

1. Arrangement of drainage systems

(d). Cover

1. Forest
2. Pasture
3. Cultivated and other crops

(e). Storage

1. Surface
2. Underground

(f). Artificial factors

1. Tillage practices
2. Erosion control practices

(g). Geological formation

(2). Precipitation

(a). Amount
(b). Intensity
(c). Duration
(d). Distribution

1. Over watershed
2. Seasonal

(3). Water disposal

(a). Evaporation
(b). Percolation

1. Groundwater reaching streams
2. Deep seepage, that is, water not appearing again in drainage channels of watershed.

(c). Interception and transpiration
(d). Surface run-off

In addition to measurements and studies of the foregoing factors, continuous records will be kept and studies made of the direction and velocity of wind, humidity, air and soil temperatures and atmospheric pressure.

VI. FORMER WORK

The San Dimas Watershed Study, which was planned by Dr. W. C. Lowdermilk and is being conducted by the California Forest Experiment Station of the U. S. Forest Service, is the most complete, detailed and comprehensive study of this nature that has ever been undertaken. The San Dimas Study relates to chaparral forest watersheds. Other important experiments relating principally to forest and herbaceous watersheds are the Emmenthal watershed experiment by Arnold Engler; the Wagon Wheel Gap Experiment by C. G. Bates and A. J. Henry; and the Great Basin experiment by C. L. Forsling. These studies will be patterned after the San Dimas study with necessary modifications to meet different conditions existing on agricultural lands.

Hydrological investigations have been in progress at all of the ten soil erosion experiment stations of the Soil Conservation Service on plots and small watersheds, and at several of the stations lysimeter studies are being carried on. Also, studies are being conducted on a few large watersheds, one of which near Pullman, Washington, has a drainage area of 18,000 acres. At several of the stations records of 5 years' duration have been obtained and have already been of value in their application to practical erosion control problems.

Numerous run-off studies on agricultural lands have been made by the Bureau of Agricultural Engineering, the most outstanding of which were conducted on the Murchison Farm near Jackson, Tennessee, and on Ralston Creek near Iowa City, Iowa. The experiments at Jackson, Tennessee, were of comparatively short duration and had for their primary object the collection of maximum rates of run-off together with coefficients of run-off for small agricultural areas applicable to the design of open ditch drainage systems, terrace systems, and small hilly watersheds ranging in area from 1 1/4 to 112 acres. The Ralston Creek rainfall and run-off studies were started in 1925 and are still being continued. They consist of rather complete studies on a single drainage basin of 3 square miles.

Run-off investigations have been conducted on many projects throughout the humid region of the U. S. by the Drainage Division of the Bureau of Agricultural Engineering on agricultural watershed areas ranging from 10 to 100 and more square miles. Outstanding among these were comprehensive investigations conducted near Urbana, Illinois, in cooperation with the University of Illinois over a five-year period to collect run-off and hydraulic data for the design of dredged drainage channels.

VII. EXPERIMENTAL PROCEDURE AS PLANNED

The general plan of study consists of First: the evaluation of all important factors by carefully conducted experimental studies; and Second: tracing the operation of such factors from small to large watersheds.

(A). The isolation and measurements of the effect of each particular factor influencing surface run-off and soil erosion is accomplished by:

(1). Tanks or lysimeters designed to measure for rainfall of different intensities, duration, and amounts.

(a). The amount and rate of percolation into the soil under different soil surface conditions.

(b). Transpiration and evaporation loss from mass of soil 3 or 4 feet deep.

(c). Influences of vegetation and organic matter on surface run-off and soil erosion.

(2). Surface run-off plots of different sizes (1/100 to 1/4 acre) and on different slopes in duplicate designed to measure the:

(a). Influence of various factors such as vegetation, tillage practices, crop rotations, and organic matter upon surface run-off and soil erosion under natural rainfall conditions.

(b). Influence of size of plot, degree of slope and length of slope upon surface run-off and soil erosion.

(c). Effect of different rainfall intensities on rate of surface run-off and soil erosion.

(B). Small watersheds of 5 to 15 acres in duplicate will be used for experiments on the effect of erosion control practices upon the rates and amounts of run-off and soil erosion for rainfall of different amounts and intensities. Erosion control practices that will be used will depend upon their adaptability to the particular region. Some of these practices will be pasture, forest, cover and green manure crops, crop rotations, various tillage methods, strip cropping and terracing. Where suitable watersheds are available, experiments will be conducted to determine the effect of shape, slope, and arrangement of drainage channels upon run-off and erosion. For instance, it is particularly desired to know the difference in run-off and erosion between concave bowl shaped watershed where the water concentrates as the streams or rivulets converge proceeding down the slopes and a convex shaped watershed where the streams diverge in traveling down the slopes. Measurements will be made to determine the effect of the various conditions and practices upon the time of concentration of the watersheds.

(C). Intermediate watersheds with areas ranging from 30 to 4,000 acres where the effect of size of watershed upon rate and amount of run-off and erosion for rainfall of different amounts, durations, and intensities will be determined. Run-off coefficients, giving both the ratio of maximum rate of run-off to maximum rate of rainfall, and the ratio of the total run-off to the total rainfall, will be determined. Also, measurements will be made to determine the time of concentration

for each watershed for different seasons of the year, for different conditions of channels, and for different rainfall intensities. Lag in the movement of run-off due to storage or other factors will also be studied.

(D). Major or Master Watersheds. Two comparable, preferably adjacent watersheds of about 5,000 acres each will be selected, one to be the medium for erosion control practices and the other to remain essentially in its original state to serve as an integrator of climatic factors. Rates and amounts of run-off and soil losses from the areas will be measured. The measurements of the total flow from the watersheds will afford a check on the sum total of the flow from all the smaller watershed units within the master watershed. Also, studies on these master watersheds will furnish information on run-off, water conservation and flood control for watersheds of the largest size for comparison with similar data obtained from the several smaller watersheds of different sizes.

(E). Complete basic surveys will be made of all the watersheds to obtain information needed in connection with studies relating to the following factors:

(1). Soil erosion survey, including regular soil survey.
(2). Topography and physiography.
(3). Geology.
(4). Land use including general cover, crops, and agricultural practices.
(5). Ground water.
(6). Economic and social conditions.

The land use survey will be repeated each year and the other surveys whenever advisable or necessary.

(F). Field Procedure and Measurements

(1). A sufficient number of automatic and standard rain gages will be distributed over the watersheds to insure the collection of accurate data of rainfall distribution and intensities as well as snowfall. All of the smaller watersheds will each have at least one rain gage.

(2). Meteorological instruments will be installed at strategic points over the watersheds and one central station will be maintained on each master watershed where measurements of temperature, wind velocities, evaporation, humidity, and atmospheric pressure will be made.

(3). Both rates and amounts of run-off and soil losses will be measured. Parshall flumes for measuring run-off, and

automatic silt samplers will be installed on the watercourses where suitable locations can be found that will be comparatively free from backwater conditions. Where Parshall flumes would not be satisfactory, current meter gaging stations will be established, and there a sufficient number of gagings will be made to define a rating curve for each station; these to be tested by occasional check gagings thereafter. Automatic water-stage recorders will be installed at Parshall flumes and gaging stations to obtain a continuous record of the waterstages, and where wide variations in the slope of the water surface of the stream occurs, measurements of the slope of the water surface will also be made when current meter gagings and daily gage readings are made.

(4). A laboratory will be installed for making the necessary silt determinations and soil analyses.

(5). Measurements will be made to determine the approximate time of concentration for each watershed. These measurements will consist of determining the velocity of the water over surface of the ground, and through drainage channels at a sufficient number of points along the travel route of water flowing from the upper end to the lower end of the main watercourse of each watershed. Measurements of velocity will be made by means of current meter or by timing the movement of floats in the streams. All of these measurements will be made for different conditions of streams and for different water stages in the channels.

(6). Measurements of run-off and erosion on the small experimental watersheds will be made in duplicate. Experimental work on these watersheds will consist of two stages:

(a). During the first stage, measurements will be made of run-off and soil losses from the duplicate watersheds in their original condition with similar vegetative cover, probably the prevailing crop rotation in the vicinity, for the purpose of determining the effect of inherent differences in the watersheds that cannot readily be evaluated. The duration of this stage will likely be from 3 to 5 years depending upon results obtained and normality of climatic and crop conditions during the period.

(b). Beginning with the second stage, erosion control practices will be established on one of the watersheds and conditions on the other watershed will remain unchanged to act as an integrator of climatic

factors. The same crop rotations will be practiced on both watersheds. The duration of the second stage will likely be 10 to 12 years, the remaining life of the experiment.

(G). Tentative Plan of Operation

Working plans will be prepared for each area as soon as the area is definitely selected, and the following preliminary work will be done:

(1). Location of experiment station headquarters and making arrangements for purchase of necessary land.

(2). Construction of laboratory, office, shops, garage and other necessary buildings.

(3). Making detailed topographic, soil, geologic, and hydrologic surveys from which gaging stations, experimental installations, test wells, and meteorological stations will be determined.

(4). Purchase and installation of standard equipment, and design, construction, and installation of special equipment.

VIII. COOPERATION

The close cooperation of the other subdivisions of the Branch of Research of the Soil Conservation Service will be sought in all matters relating to their fields of work.

It is proposed to establish cooperative relations with all Federal Bureaus, State Departments, Experiment Stations, Agricultural and Engineering Colleges, Hydraulic Laboratories, and other public and private agencies engaged in lines of work related to the studies to be conducted on the watersheds.

Where deemed necessary and in the public interest, outstanding authorities on the various phases of the work will be engaged as consultants.

IX. PROPOSED EXPENDITURES

It is, of course, impossible to give specific figures for the various items before the areas are selected and a complete field reconnaissance survey of each of the watersheds is made. The figures given below are necessarily of a rather general character and should not be used as actual cost estimates. The proposed expenditures given below are divided into two major groups:

(A)., Initial Expenditures; (B)., Operating Costs.

(A). Initial Expenditures: (the figures given under this heading cover the temporary, technical, and supervisory personnel in connection with the design and construction of the various installations.)

(1). Survey.

(a). Aerial Survey.

1.	Flying	$600.00
2.	Ground Control	200.00
3.	Planimetric Map	100.00
4.	Mosaic	100.00
	Total	$1,000.00

(b).	Topography	$1,500.00
(c).	Soil Erosion & Land Use	2,000.00
(d).	Vegetation	2,000.00
(e).	Geology and Ground-water	500.00

Total Surveys ------------------------ $6,000.00

(2). Laboratory.

(a).	Building	$5,000.00
(b).	Equipment	3,000.00

Total --------------------------------- $8,000.00

(3).	Office Building and Equipment	$5,000.00
(4).	Engineering Instruments & Equipment	3,000.00
(5).	Shops and Garages	2,000.00
(6).	Implements and Tools	8,000.00
(7).	Vehicles and Trucks	10,000.00
(8).	Road Improvements (bridges, culverts, etc.)	10,000.00
(9).	Lysimeters, control plots, silt boxes, and other installations	50,000.00
(10).	Gaging stations (Parshall Flumes and other controls) including waterstage recorders	30,000.00
(11).	Ground-water wells equipped with water level recorders	5,000.00

(12). Meteorological Equipment:

(a).	200 Standard Gages	$2,000.00
(b).	20 Recording Gages	4,000.00
(c).	5 Central Stations @$1,500	7,500.00

(d). Soil Thermographs, Hygrothermographs, and other recording equipment -------------------- $5,000.00

Total -- $18,500.00

(13). Land Easements or Purchases --------------------- 50,000.00

Total Initial Expenditures for One Watershed -----$201,000.00

(B). Operating Costs - One Year

(1). Field Personnel: (under each position are given the general duties).

Superintendent in Charge -------------------------- $3,800.00
(To administer the work, to have general supervision and be responsible for carrying out the studies in accordance with the approved working plan).

Assoc. Hydrologist -------------------------------- 3,200.00
(In charge of all Hydrologic work, direct supervision of water and silt run-off).

Assistant Hydrologist ----------------------------- 2,600.00
(Direct supervision of all meteorologic observations).

Junior Hydrologist -------------------------------- 2,000.00
(Under the direction of the Hydrologist to conduct ground-water and soil moisture studies).

5 Aides, at $1,620 -------------------------------- 8,100.00
(Assist in the collection of Hydrologic data).

Soil Technologist --------------------------------- 3,200.00
(In charge of all soil analysis and studies, direct supervision of the laboratory studies).

Assistant Soil Technologist ----------------------- 2,600.00
(Supervision and direction of detailed periodic soil surveys and studies).

Junior Soil Technologist -------------------------- 2,000.00
(To assist the Soil Technologist in laboratory and other studies).

3 Aides at $1,620 -------------------------------- (Make routine determinations in the laboratory and collect soil samples in the field).	$4,860.00
Agronomist ------------------------------------ (To have charge of the Vegetative phase of the work; to direct crop rotation experiments).	3,200.00
Junior Agronomist ----------------------------- (To assist the Agronomist in field and office work).	2,000.00
Assoc. Agricultural Engineer ------------------ (To have charge of all terracing, tillage experiments and agricultural machinery).	3,200.00
Junior Agricultural Engineer ------------------ (To assist the Agricultural Engineer in field and office work).	2,000.00
1 Clerk --------------------------------------- (To take care of the routine fiscal and administrative matters).	1,800.00
2 Stenographers at $1,440 ----------------------	2,880.00
1 Skilled Mechanic ----------------------------	2,000.00
1 Assistant Mechanic --------------------------	1,620.00
Janitors and Laborers -------------------------	7,500.00
Total Personnel for One Year ------------------	$54,560.00

(2). Miscellaneous Operating Expenses

Heat, power, light and telephone --------------	$1,800.00
Gasoline and Oil ------------------------------	3,000.00
Farm Operation Expenses -----------------------	5,000.00
Maintenance of buildings, replacement and repair of equipment --------------------------	5,000.00
Laboratory and office supplies ----------------	740.00
Total ---	$15,540.00
Total Operating Costs for One Year ------------	$70,100.00
TOTAL FIRST YEAR EXPENDITURES ON ONE WATERSHED (Assuming that all construction and installations will be completed during the first year). -------------------------	$271,100.00
GRAND TOTAL FOR TEN WATERSHEDS -------------	$2,711,000.00

X. ASSIGNMENTS

C. E. Ramser will be in charge of the Watershed Studies under the direction of W. C. Lowdermilk, Associate Chief of the Soil Conservation Service. D. B. Krimgold, Associate Hydrologist, has been assigned to the staff in the Washington Office.

XI. LITERATURE CITED

(A). Bates, C. J., and Henry, A. J.
Forest and Streamflow Experiment at Wagon Wheel Gap, Colorado. Monthly Weather Review Supplement No. 30 U. S. D. A. Weather Bureau, 1928.

(B). Dort, J. C.
Report on Cooperative Streamflow Study, Los Angeles County, 1916-1920.

(C). Forsling, C. L.
A study of the influence of herbaceous plant cover on surface run-off and soil erosion in relation to grazing on the Wasatch Plateau in Utah, U. S. D. A. Technical Bulletin No. 220.

(D). Lowdermilk, W. C.
Investigative Program Reports for Project of Forest Influences, California Forest Experiment Station, 1928, 1929, 1930, 1931, MS. Berkeley, California.

Lowdermilk, W. C.
Influence of Forest Litter on Run-off, Journal of Forestry, April 1930, pp 476-491.

Lowdermilk, W. C. and Row, P. B.
Still further studies on absorption of rainfall on the relation of surficial run-off and erosion; Transactions of the American Geophysical Union, Fifteenth Annual Meeting, Part II.

Lowdermilk, W. C.
Watershed and Water Conservation Study in the Chaparral Regions of California, California Forest Experiment Station, Berkeley, California, 1932.

(E). Norton, Robert A., Ramser, C. E., and Pickles, G. W.
Run-off Investigations in Central Illinois, Mimeographed Report, 1931, Bureau of Agricultural Engineering, U. S. D. A.

(F). Ramser, C. E.
Run-off from Small Agricultural Areas, Journal of Agricultural Research, Vol. 34, No. 9, May 1, 1935.

Ramser, C. E.
Run-off Investigations and Determinations of the Roughness Coefficient for Kutter's Formula Made in Lee County, Mississippi, January, 1915; Mimeographed Report, Drainage Investigations, Office of Experiment Stations, U. S. D. A.

Ramser, C. E.
Run-off Investigations in Western Iowa; Mimeographed Report, April 1919, Drainage Investigations, Bureau of Public Roads, U. S. D. A.

Ramser, C. E.
Investigations pertaining to Run-off from Farm Lands in Murray County, Minnesota; Mimeographed Report, Bureau of Agricultural Engineering, U. S. D. A.

Ramser, C. E.
Run-off Investigations in Western Tennessee; Mimeographed Report, 1919, Drainage Investigations, Bureau of Public Roads, U. S. D. A.

(G). Bartel, F. O.
Run-off Investigations on Third Creek, Iredell County, N. C., 1927. Bulletin published by North Carolina Agricultural Experiment Station.

(H). Leach, H. R., Cook, H. L. and Horton, R. E.
Storm Flow Prediction; Transaction of the American Geophysical Union, 1933, pp 435-446.

(I). There are numerous other articles and publications dealing with some phases of watershed studies and the reader is especially referred to those published by the U. S. Geological Survey, the American Geophysical Union, and the American Society of Civil Engineers.

APPENDIX II

SELECTION OF AN EXPERIMENTAL WATERSHED
FOR
THE NORTH APPALACHIAN REGION

by

D. B. KRIMGOLD
UNDER THE DIRECTION OF
MR. C. E. RAMSER, CHIEF,
SECTION OF WATERSHED AND HYDROLOGIC STUDIES

A P P E N D I X II

SELECTION OF AN EXPERIMENTAL WATERSHED FOR THE NORTH APPALACHIAN REGION

Table of Contents

SELECTION OF AN EXPERIMENTAL WATERSHED IN THE NORTH APPALACHIAN REGION

by D. B. Krimgold
Under the Direction of Mr. C. E. Ramser
Chief of the Division of Watershed and Hydrologic Studies

ACKNOWLEDGMENTS

From ten to fifteen members of the Washington and the Salt Creek (Ohio) project staffs of the Soil Conservation Service were employed under the direction of the writer in the selection of the experimental watershed in the North Appalachian Region described in the following pages.

The method employed in the selection was devised by the writer and approved by Mr. C. E. Ramser, Chief, Division of Watershed and Hydrologic Studies. Mr. H. L. Cook and Dr. H. E. Middleton of the Section of Erosion Investigations cooperated with the writer in working out the details of procedure followed in the office study. The Section of Watershed and Hydrologic Studies did not have a staff of its own, and it was therefore necessary to borrow the required personnel from other divisions of the Soil Conservation Service. Mr. Fuller, in charge of the Division of Conservation Surveys, and Mr. J. S. Cutler, Regional Director of the Salt Creek (Ohio) Project of the Soil Conservation Service, furnished the necessary personnel.

Mr. J. S. Cutler and various members of his staff; Mr. Bryce Browning, Secretary-Treasurer, and Mr. C. C. Chambers, Chief Engineer, Muskingum Watershed Conservancy District; and Mr. Wilbur Stout, State Geologist of Ohio, cooperated with the writer in the studies carried out in the field and rendered valuable advice and assistance. Thanks are due to Messrs. S. D. McElroy and H. Murto of the Washington Office, Soil Conservation Service drafting room staff and to Messrs. R. B. Hickok and George Sherman, Engineers of the Salt Creek Project, for assisting in the preparation of the numerous maps and tables. Mr. W. F. Beamon, Chief Draftsman, and his assistants rendered valuable aid in securing the various maps and reports and in supplying the necessary facilities.

INTRODUCTION

The results of the experiments carried out on the Soil Conservation Service Erosion Experiment Stations and of the work on the Soil Conservation Service Demonstration Areas as well as observations on well-managed farms indicate that erosion control measures and proper land use practices result in greatly alleviating such consequences of accelerated erosion as the removal of valuable top soil, the destruction of large tracts of land by gullying or deep deposits of coarse material, and the silting of expensive artificial reservoirs and irrigation structures.

Accelerated water-born erosion and its devastating consequences are caused by the destructive force of running water. Erosion control measures and proper land use practices are effective in controlling

erosion because they tend to retard the rate and reduce the amount of surface run-off by preventing excessive concentration of water resulting from heavy rains, by increasing the "infiltration opportunity", by modifying the soil so as to increase both its water-holding capacity and the rate of percolation through it, and by binding the soil and protecting it from the effects of beating rain drops and the erosive force of surface run-off. The above are accomplished by terracing and other engineering methods of control, by strip cropping, proper tillage and fertilization, and by maintaining an adequate protective vegetative cover.

Hydrologically, erosion control measures and proper land use practices tend to diminish the rates of run-off and to modify the disposal of precipitation by increasing percolation and evapo-transpiration at the expense of surface run-off. The quantitative determination of the extent to which the rate of run-off and disposal of precipitation are modified by erosion control measures and proper land use practices is necessary in order to ascertain their full economic importance and the optimum extent to which such measures and practices are justifiable. It is also important to determine to what extent costly flood control reservoirs, detention dams, and other regulating works can be economically supplemented or safely replaced by the application of erosion control measures and proper land use practices on the contributing watersheds.

The task of making such determinations in typical agricultural regions of the United States was assigned to the Division of Watershed and Hydrologic Studies of the Soil Conservation Service. A "PROVISIONAL WORKING PLAN FOR WATERSHED STUDIES RELATING TO WATER CONSERVATION, FLOOD CONTROL, AND RUN-OFF AS INFLUENCED BY LAND USE AND METHODS OF EROSION

CONTROL, TO BE CARRIED ON IN TYPICAL AGRICULTURAL REGIONS OF THE UNITED STATES" was prepared by the Division. The program as outlined in the "PROVISIONAL PLAN" calls for the establishment of ten experimental watersheds in the various regions of the United States on which comprehensive studies will be carried on for a period of from twenty to thirty years.

The purpose of the studies, the long time and the ultimate cost involved, make the selection of the sites for the experimental watersheds a matter of major importance. The method and procedure which were developed for the selection of the general regions and of the experimental watershed in the North Appalachian Region are fully described below under (A) and (B).

(A). SELECTION OF TYPICAL AGRICULTURAL REGIONS IN THE UNITED STATES

The factors considered in the selection of typical regions are:

1. Principal drainage basin
2. Physiographic province
3. Climatic province
4. Major soil type
5. Major type of erosion
6. Major land use practices
   (Including prevailing crops and
   methods of cultivation)

A study of: "THE REPORT OF THE NATIONAL RESOURCES BOARD", "THE ATLAS OF AMERICAN AGRICULTURE", "THE 1930 AGRICULTURAL CENSUS REPORT" and other publications resulted in the selection of tentative

general locations representing the various regions. These were plotted on a map of the United States as shown in Figure II-A. The circles shown in Figure II-A represent the centers rather than the boundaries of the regions. In the actual selection of suitable areas within any given region whole states and portions of states falling within a given region are considered.

(B). SELECTION OF AN EXPERIMENTAL WATERSHED FOR THE NORTH APPALACHIAN REGION

The type of information to be secured in the early stages of the studies is urgently needed by existing and proposed flood control projects in the Region. This, and the availability of maps and other information pertaining to the North Appalachian Region which would tend to expedite the preliminary studies, made it desirable to establish the first experimental watershed in that Region.

For the purposes of the watershed studies the North Appalachian Region designates the state of West Virginia, the western part of Pennsylvania, the eastern half of Ohio and the northern part of Kentucky. The method and procedure developed in the selection of the experimental watershed for this Region (with slight modification) will be used in the selection of the watersheds for the remaining Regions. The selection consists of three major steps which are described below.

STEP I. SELECTION OF SUITABLE AREAS WITHIN THE REGION

The "Provisional Plan" stipulates that each of the watersheds to be established is to be representative of the region in which it is

located with respect to: 1. Nature and extent of erosion, 2. General soil type, 3. Predominating land use practices, 4. Type of topography, 5. Geology as related to ground water conditions.

The problem of selecting suitable areas within the North Appalachian Region is thus resolved into:

Firstly, determining for the Region (a) the most prevalent type of erosion, (b) the major soil type, (c) the prevailing land use practices, (d) the prevalent type of topography, (e) the major geologic formation.

Secondly, eliminating areas not typical with respect to any of the above factors, thus arriving at a small area within the region which is representative with respect to all of the factors; on the area thus obtained to designate a number of available watersheds for a comparative study of their characteristics. The problems involved in Step I were solved in the following way:

Numerous maps and reports giving information on the various factors mentioned above were secured and studied in detail. It was found that the information given in the Reconnaissance Erosion Survey maps of the United States and of the states comprising the North Appalachian Region, prepared by the Soil Conservation Service, was sufficient to determine the prevalent general type of erosion. The Soil Map of the United States by the late C. F. Marbut and his associates was found adequate for the purpose of determining the major soil types. A map entitled "Natural Land Use Areas of the United States", published by the Bureau of Agricultural Economics, showed the topography of the

region in sufficient detail to determine the prevalent type. The prevailing land use practices were found adequately represented on a map entitled "The Regionalized Types of Farming Based on the 1930 Census", published by the AAA. The major geologic formations were represented on the geologic map of the United States.

Of the above mentioned, the soil and geologic maps were on a scale of 1 to 2,500,000; the remaining three were on a scale of 1 to 5,000,000. Copies of all these maps and of a map of the United States showing state and county boundaries on a scale of 1 to 2,500,000 were secured. Several copies of tracings showing the boundaries of the states and portions of states included in the region were made from the latter. The information on the various factors as given in the above listed maps was transferred onto the tracings by superimposing and by means of proportional dividers and pantograph. This resulted in Figures II-1, -2, -3, -4, and -6, which represent the several types of erosion, the various soil types, the several land use practices, the types of topography (physiography) and the several geologic series within the region respectively. The major types were then determined and cross-etched in contrasting symbols. The legends of Figures II-1, -2, -3, -4, and -6 are self-explanatory and give the names of the various types.

Having determined the major types it was then necessary to eliminate the portions of the region which were not typical with respect to all of the factors considered. This was accomplished by means of Figure II-5, designated as "the preliminary composite" in the following

manner. A blank tracing showing the boundaries of the states was superimposed over Figures II-1, -2, -3, and -4 in succession. In each case the non-typical areas were cross-etched on Figure II-5 with the symbol used in representing the major type on the preceding drawing. Thus, in superimposing Figure II-5 over II-1, all areas except the major type were cross-etched or ruled out and therefore eliminated, leaving blank only the portion cross-etched in Figure II-1. Figure II-5 was then superimposed over Figure II-2 and the portions of the blank area falling without the boundary of the major soil type (Muskingum Series) were cross-etched. This resulted in further reduction of the blank area which was now representative of both the major erosion and major soil types in the region. The same process was repeated with Figures II-3 and II-4 and as a result, the blank area lying within the heavy black line in Figure II-5 and designated in the legend as "Residual Areas" was arrived at. The areas were thus known to be typical of the region with respect to erosion, soil, land use, and topography in accordance with the best information available.

It may be well to state that the order in which the figures II were superimposed was not chosen arbitrarily. Figure II-1, representing the erosion factor, was used first because the type and degree of erosion are related to the soil type, land use, and type of topography as well as to the amount and intensity of precipitation and to the type and density of vegetation. This relation was represented in the form of a functional equation by L. D. Baber in "Some Soil Factors Affecting Erosion" (Agric. Eng. v14, n2, 1933) as:

$$E=f(R,G,W,S)$$

It was later modified by Professor A. M. Pankov (Leningrad, U.S.S.R.) in "To the Geography and Cartography of Soil Erosion", (Pochvovedenie-Pedology n6, 1934) as follows:

$$E = f(R,G,W,S,T,C)$$

where E = soil erosion; R = amount and intensity of precipitation; G = size and slope of area; W = nature and density of vegetation; S = physical properties of the soil; T = length of time the soil was under cultivation; C = the sum total of conditions of land use.

The preliminary composite (Figure II-5) was then superimposed over Figure II-6 showing the geologic formations, and the area arrived at was found to lie within the carboniferous series. This indicated the possibility of coal mining and of gas and oil developments which might affect the ground water phase of the studies to be made and the acquisition of the necessary control of the land. To determine the portions of this area known to be affected by commercial mining, a large scale geologic map of the state of Ohio (1921) showing the locations of coal, oil, and gas fields was secured. A blank tracing was made and the "Residual areas" were traced from Figure II-5. It was then superimposed over the United States map giving county lines and county seats and Figure II-7, "Auxiliary Map" was obtained. An additional copy of Figure II-7 was made on which, for the sake of clearness, the names of the counties and county seats were left out. With the aid of the "Auxiliary Map" the information from the geologic map of Ohio was transferred onto Figure II-8 which shows the portions of the areas geologically suitable and those geologically unsuitable. A duplicate

of Figure II-5 was then superimposed over Figure II-8 and the geologically unsuitable areas were eliminated. This resulted in Figure II-9, designated as "Final Composite". The blank areas lying within the black lines in Figure II-9 and designated as "Residual areas", thus represent small areas typical of the North Appalachian Region with respect to erosion, soil, land use, and general topography (physiography). These areas are also reasonably safe with respect to mining, gas, and oil developments. With the information represented in Figure II-9, STEP I of the selection was concluded.

To determine the number of acres within the United States represented by the areas thus selected with respect to erosion, soil, and land use, Figures II-10, -11 and -12 were prepared. These figures show that 63,000,000 acres in the United States are subject to the type of erosion represented by the areas selected, that the Muskingum Soil Series represents 80,000,000 acres in the United States, and that the type of land use represented by the selected area represents 97,800,000 acres in the United States.

STEP II - A CRITICAL STUDY OF COMPARATIVE CHARACTERISTICS OF AVAILABLE WATERSHED SITES.

Having arrived at comparatively small suitable areas within the region, it was now necessary to

<u>Firstly</u>: determine the required characteristics of the watershed to be selected.

<u>Secondly</u>: designate available watersheds within the suitable areas.

<u>Thirdly</u>: to make a critical office and field study of the comparative characteristics of the designated watersheds.

The purposes for which the experimental watersheds are to be established are stated in the "PROVISIONAL PLAN" as follows:

1. To determine the effects of proper land use and erosion control practices upon soil and water conservation and upon flood flows.
2. To trace these effects as demonstrated by studies of small plots and lysimeters through small, intermediate, and large watersheds.
3. To determine rates and amounts of run-off caused by precipitation of various amounts, intensities, and time of occurrence on watersheds varying in: (a) size, (b) shape, (c) soil, (d) topography, (e) vegetative cover, (f) land use and tillage practices, (g) erosion control measures, (h) underlying geologic formations as affecting ground water conditions.

To be suitable for the purposes outlined above, the selected watersheds must have the following characteristics:

1. Number and type of watersheds.

   Three possible arrangements were considered:

   <u>First</u>: Two adjoining master watersheds of about 5,000 acres each were to be used. On one of them, to be known as the "Control", the various control studies of lysimeters, plots, and small watersheds

were to be made in accordance with the plans described in the "DETAILED WORKING PLAN". The run-off from the intermediate watershed, lying within the "control" master watershed, was to be studied in two stages. During the first stage, lasting through a cycle of normal precipitation, the amounts and rates of soil and water run-off were to be determined under conditions of prevailing land use practices. During the second stage, lasting through the life of the experiment, the above determinations were to be made under conditions of proper land use and erosion control measures. On the adjoining master watershed the rates and amounts of run-off from the entire watershed and from the intermediate watersheds were to be measured under conditions of prevailing land use practices during the entire life of the experiment. This watershed was to be known as the "check".

<u>Second</u>: Under the second arrangement, the treatment was to be as above described except that instead of a master adjoining watershed, a number of adjoining intermediate watersheds were to be used as "checks".

<u>Third</u>: Under this arrangement several pairs of adjoining intermediate watersheds lying in the vicinity of the master watershed, but not necessarily adjoining it,

were to be employed in addition to the master "control" watershed. In each pair, one was to serve as the "control" and the other as the "check".

2. Size, Shape, and Drainage Characteristics

The master watersheds are to be about 5,000 acres in size in order that ample perennial flow may be assured in the main stream, thus making it possible to gage the flow with a sufficient degree of accuracy at all times.

To make the interpretation of the run-off data simpler and to avoid complicated hydrographs, it is important that the watershed should be nearly symmetrical with respect to the main axis (major stream), and should have a fairly regular shape. To facilitate the study of the effect of aspect it is necessary that the various portions of the watershed should have different exposures.

3. Topography.

The topography of the master control watershed must be typical of the region with regard to slope distribution. The master watershed must contain at least 18 small watersheds ranging in size from 5 to 15 acres. Eight of these must fall within the slope group of 20 percent and up; two of the eight being in timber. Of the remaining ten, five must fall within the slope group of 12 percent to 20 percent and five within the slope group of 0 percent to 12 percent. (See "Schedule of Operations on Small Watersheds" in the "Detailed Working Plan"). The master watershed should contain a large number of intermediate watersheds of various sizes and shapes.

4. Soils.

To reduce the number of variables involved, it is desirable that the soil on the watershed be all of the same series.

5. Gaging Sites.

The watershed must contain a sufficient number of feasible gaging sites.

6. Geologic Formation.

The watershed should be free from faults, mines, and other non-conformities so that the disposition of all precipitation on the watershed can be readily accounted for through evaporation, transpiration, surface and subsurface flow.

7. Control of the Land and Land Use Practices.

These must be assured by cooperative agreements with land owners and farmers on the master watershed and by outright purchase or long-time leases of certain portions of it needed for small watersheds, plots, lysimeters, gaging station and building sites.

8. General Facilities.

The watershed must be accessible by all-weather roads, and must be reasonably near to sources of electric power and/or gas and to telephone lines.

The designation of the available watersheds within the suitable areas was made with the three possible arrangements and the required characteristics above described in mind. The procedure employed was as follows:

An index to the topographic survey of the state of Ohio was secured from which the quadrangles covering the residual areas given in Figure II-9 were determined. These were mounted on five large sheets consisting

of from four to six quadrangles. These, together with relief maps of the states of Ohio, Kentucky, West Virginia, and Pennsylvania, served to determine the detailed topography typical of the region.

Eighty-six watersheds, ranging in size from 192 acres to 7,514 acres and representing groups of various combinations, were outlined on the topographic maps as shown in a sample, Figure II-13. The master watersheds were designated by capital letters. The intermediate watersheds, either adjoining or adjacent to a group of master watersheds, were designated by corresponding small letters. Thus W, W', W", designate a group of three master watersheds of which at least two are adjoining; and "w" designates an intermediate watershed either adjoining or adjacent to the W group. One master watershed was designated as L"-Q", indicating that it is adjoining to master watersheds of both the Q and the L groups. Intermediate watersheds not in the close vicinity of any group of master watersheds were designated by numerals; thus, 5 and 5' designate two intermediate adjoining watersheds located some distance away from any group of master watersheds.

After designating the various watersheds on the maps, Table #1, entitled "Comparative Characteristics of Watersheds in the North Appalachian Region" was prepared. The thirty-two columns comprising the table represent most of the characteristics investigated for the majority of the eighty-six watersheds. The watersheds were listed in column 1 of the table and all the information relating to them derived from the topographic map and from the various publications available in the Washington office was tabulated in columns 1 to 11, 14, and

18 to 21 inclusive. To complete the remaining columns, it was necessary to secure information by actual field surveys.

Arrangements were made with the Regional Director of the Salt Creek Project of the SCS for the necessary personnel and facilities needed in conducting the field studies. The writer collected the maps and information resulting from the Washington office Study and proceeded to Zanesville, Ohio, which served as the headquarters from which the field studies were conducted.

The large number of watersheds to be investigated in the field (86) was chosen in order to have sufficient latitude and freedom in eliminating those which, in the light of information secured locally, would prove undesirable. Before proceeding with actual field investigations of the large number of watersheds it was decided to consult local people with regard to the suitability of the various groups. For this purpose, a conference of all members of the technical staff of the Salt Creek Project and of the Soil Erosion Experiment Station of the SCS and other interested persons was called. The objectives of the studies to be made were carefully explained and discussed at this conference. Following the conference, each of the participants was individually interviewed by the writer. The topographic maps showing the various areas were studied during these interviews and the testimony of each member of the staff relative to every watershed was recorded. A total of 16 persons were interviewed. Samples of their testimonies, with notes giving their qualifications, are given on Pages II-29 to II-33.

During the interviews the attention of the writer was called to the reservoirs of the Muskingum Watershed Conservancy District, which might affect some of the watersheds to be investigated, and to a recent map showing the mineral industries of Ohio. The spillway and normal pool elevations of the Muskingum Watershed Conservancy District reservoirs were obtained from the U. S. Engineer Office at Zanesville and the normal pool and spillway water lines were plotted on the topographic maps as shown in Figure II-13. It was found that only one watershed was affected by the normal pool of the reservoirs and that very few were affected by the spillway elevation water lines.

A copy of the Mineral Industries map was secured and the information from it was pantographed onto the topographic maps as shown in Figure II-13.

As a result of the conference and of the interviews, twenty-five watersheds were eliminated. The reasons for elimination are given in column 32 of Table #1. It will be noted that a large group of watersheds was eliminated because the possibility of signing cooperative agreements with the farmers of that section was precluded on religious grounds (The Amish people do not sign contracts). In the course of the conference and the interviews, it was also found that reconnaissance surveys of the soil, slope, and land use were made of the entire Muskingum Conservancy District during 1934. The results of these surveys plotted on U. S. Geological Survey quadrangles were available at the Zanesville office of the Soil Conservation Service. The remaining sixty-one watersheds to be investigated were found to lie within the

boundaries of the Muskingum Watershed Conservancy District. The boundaries of these watersheds were transferred onto the survey maps and the information relating to the soils, slope distribution, and land use on each of them was obtained by planimetering and computing the areas indicated by the symbols used in designating the various factors. This information was tabulated in columns 12, 15, 16, 17, 22, 23 and 24 of Table #1. Figure II-14, with the explanatory legend attached to it, represents a sample of the maps used in obtaining the information. This information was also tabulated in Table #2 entitled "Study of Slope Distribution and Land Use on Proposed Experimental Watersheds" and was subjected to a statistical analysis. With this analysis STEP II of the selection was concluded and the field inspection of suitable watersheds leading to the final selection was begun.

STEP III. FIELD INSPECTION OF SUITABLE WATERSHEDS AND FINAL SELECTION OF THE EXPERIMENTAL WATERSHED

The results of the analysis and of the interviews were discussed with Mr. J. S. Cutler, Regional Director, and the number of watersheds to be further investigated was again reduced. The remaining twenty-five or thirty watersheds were inspected in the field by the writer, accompanied by Mr. W. B. Oliver, Soil Expert of the Zanesville SCS Office, and other members of the staff. Copies of the notes taken in the field are given on Pages II-34 to II-37. As a result of the actual field inspections which involved approximately 1,500 or 2,000 miles of travel, all of the watersheds with the exception of L, L', Q, Q', S, S', W, W", V, C, C', C", and c_1 were eliminated. Mr. Wilbur Stout, State

Geologist of Ohio, was then consulted with regard to the remaining areas. Upon his suggestion the areas C, C', C", c_1, S, S' were eliminated. The reasons for the elimination are given in column 32 of Table #1.

During the field investigations it became apparent that of the possible arrangements discussed under STEP II, (see Page II-10), the second arrangement was the most practical one under local conditions. The detailed field reconnaissance surveys of the six watersheds were made with this arrangement in mind. These surveys consumed about ten days and were made by Mr. C. E. Ramser and the writer.

The procedure employed in the detailed surveys of the six watersheds was as follows:

Enlargements of the topographic maps of these watersheds were made. All of the available roads within each watershed were traveled and the various pertinent features were recorded. Each item of information relating to any portion of the watershed was designated by a number, and the corresponding location on the map was indicated by the same number. Where no roads were available, the work was done on foot. A sample of the resulting maps, with the corresponding notes attached, is given in Figure II-15. After completing the detailed surveys, property maps of the watersheds were obtained from the county surveyors of Coshocton, Tuscarawas, Carroll, and Holmes Counties. On these maps were plotted the approximate sites on which long time leases and complete title to the land will be needed. The county agents of the above mentioned counties were consulted with regard to the cooperation

to be expected from the farmers. A sample of these maps, shown in Figure II-16, was given to Mr. Bryce C. Browning, representing the Board of Directors of the Muskingum Watershed Conservancy District. The Board and the Chief Engineer of the District are vitally interested in the studies to be made on the Experimental Watersheds and have been cooperating with the Soil Conservation Service in securing the necessary control of the land.

On September 3, Mr. H. H. Bennett, Chief, and Dr. W. C. Lowdermilk, Associate Chief of the Soil Conservation Service, inspected the watersheds Q and W" which were considered the best of the six. The information secured by Mr. Browning indicated that there will be no serious difficulty in securing the necessary cooperation on either Q or W". The problem thus narrowed down to a close study of the comparative characteristics of the two watersheds, which is given on the following pages.

A STUDY OF COMPARATIVE CHARACTERISTICS OF WATERSHEDS Q AND W"

Note: The characteristics and information tabulated below were taken from Tables 1, 2, and 3, and from the various accompanying Figures:

	WATERSHED Q	WATERSHED W"
1. SIZE AND SHAPE:		
(a) Size.	Watershed Q comprises an area of 7.63 sq. miles or 4,883 acres.	Watershed W" comprises an area of 6.39 sq. miles or 4,090 acres.
(b) Shape.	The average width of Q is 1.5 miles and its length is 5.2 miles. The watershed is narrow at its headwaters, widens out towards the middle and narrows down again towards the discharge end. Its shape is designated as "Leaf".	The average width of W" is 1.7 miles, its length is 4 miles. The watershed is narrow at headwaters, widening out towards the middle, and narrowing down towards the end. Its shape is designated as "Leaf".
(c) Symmetry. (The ratio of the area lying on one side of the major axis to that lying on the opposite side)	The symmetry of Q is one to one (nearly perfect)	The symmetry of W" is one to two.

	WATERSHED Q	WATERSHED W"
2. LOCATION	Watershed Q is located in Millcreek and Crawford Townships of Coshocton County in the State of Ohio. The center of the Watershed is 8.5 miles north of the city of Coshocton, population 11,000. It is located approximately 34.5 miles east of the Erosion Experiment Station at Zanesville, Ohio.	Watershed W" is located in the Lee and Union Townships of Carroll County, of the State of Ohio. The center of the Watershed is 4 miles southeast of the town of Carrollton, population 2,500. It is located approximately 67 miles northeast of the Erosion Experiment Station at Zanesville, Ohio.
3. SOILS	94.1% of the soil of Watershed Q is of the Muskingum series.	83% of the soil of Watershed W" is of the Muskingum series.

4. GEOLOGY

The geologic conditions of both Watersheds are satisfactory (according to Mr. W. Stout, State Geologist).

	WATERSHED Q	WATERSHED W"
5. TOPOGRAPHY		
(a) Range in Elevation	The elevations within the Watershed Q range from 820 to 1,220 above sea level. This is close to the average for all the watersheds investigated. (See Table #1, column 14)	The elevations within Watershed W" range from 1,020 to 1,300. This is above the average for the watersheds investigated. (See Table #1, column 14).

	WATERSHED Q	WATERSHED W"
(b) Slope Distribution	29.2% of the area of Watershed Q falls within the "0 to 12%" slope group, 7.6% of the area falls within the "12% to 20%" slope group, 63.2% of the area falls within the "20% and up" group.	6.0% of the area of Watershed W" falls within the "0 to 12%" slope group, 49.4% of the area falls within the "12% to 20%" group, 44.6% of the area falls within the "20% and up" group.

The "20% and up" group was chosen as the criterion for topography and was found to be 52.4% for a total of 204,780 acres representing areas scattered throughout the Muskingum watershed.

	WATERSHED Q	WATERSHED W"
	The percent deviation from the mean for Q equals $\frac{63.2 - 52.4}{52.4} \times 100 = + 21\%$	The percent deviation from the mean for W" equals $\frac{44.6 - 52.4}{52.4} \times 100 = -15\%$

6. DRAINAGE CHARACTERISTICS

	WATERSHED Q	WATERSHED W"
(a) Streams	The principal stream of the watershed, known as Little Mill Creek, drains into Mill Creek, which empties into the Walhonding river. The drainage is quite simple and regular.	The watershed is drained by two main forks of McQuire Creek, which empties into the Conottan Creek. The drainage is rather complex and irregular.
(b) Small and Intermediate Watersheds	Watershed Q is composed of 19 intermediate watersheds ranging in size from 42 to 532 acres. A sufficient number of small watersheds of the various slope classes is available on Watershed Q and in the immediate vicinity of it. (see Figure 2 of "Detailed Working Plan").	Watershed W" is composed of 12 intermediate watersheds ranging in size from approximately 60 to 400 acres. A sufficient number of small watersheds of the various slope classes is available within the watershed (see Figure II-17).

	WATERSHED Q	WATERSHED W"
(c) Aspect.	The aspect of Watershed Q as determined by inspection of the topographic map is as follows: 20% northwest, 20% southwest, 30% northeast and 30% southeast. (see Table #1, column 21).	The aspect of Watershed W" as determined by inspection of the topographic map is as follows: 30% north, 10% south, 30% east, and 30% west. (see Table #1, column 21).
7. VEGETAL COVER	The Vegetal cover of Watershed Q is distributed in the following way: Timber 9%, percent deviation from mean -- -43; Grasslands 46%, percent deviation from mean -- -11. Crops 45%, percent deviation from mean -- +38.	The Vegetal cover of Watershed W" is distributed in the following way: Timber 22%, percent deviation from the mean -- +40. Grasslands 41%, percent deviation from mean -- -21. Crops 37%, percent deviation from mean -- +14.
8. FACILITIES AVAILABLE		
(a) Bench Marks	There are 9 bench marks within the watershed Q and in its immediate vicinity.	There are 6 bench marks within the Watershed W" and in its immediate vicinity.
(b) Maps	An aerial survey of Coshocton county was recently made by the National Guard of Ohio. Contact prints covering the watershed are in the possession of the SCS. An accurate topographic map on a scale of 1" = 500 ft. of the	No aerial survey was made of Carroll county and it will be necessary to fly the area in order to obtain the necessary prints. This may take from 3 to 4 months and will cost about $4,000.

	WATERSHED Q	WATERSHED W"
	master and the adjoining intermediate watersheds, as shown in Figure 2 of "Detailed Working Plan", can be made in from one to two months at a total cost of $1,325.	
(c) Roads.	A fair gravel road is available through the entire length of Watershed Q. A good system of secondary ridge roads, on which considerable work should be done, is available.	The Ohio State Highway, No. 43, traverses the Northern portion of Watershed W". State Highway, No. 9, follows the eastern boundary of the watershed. Few secondary roads are available, of which only one is in fair condition. It will be necessary to construct a considerable number of new roads.
(d) Electricity & telephone	Electricity and telephone can be made available by constructing a short pole line from Highway #76, lying within a couple of miles of the watershed.	Electricity is available from Carrollton. Telephone lines follow Highways Nos. 43 and 9.
(e) Gaging Sites.	Nineteen good gaging sites are available for the intermediate watersheds in addition to six feasible sites along the main stream.	Fair gaging sites are available for most of the intermediate watersheds and along the main forks.
9. LAND OWNERSHIP AND VALUE		
(a) Ownership.	The land within watershed Q is owned by 45 property owners most of whom,	The land within watershed W" is owned by 50 property owners. A considerable

	WATERSHED Q	WATERSHED W"
	according to the testimony of local men, will be easy to cooperate with.	portion of the land is owned by absentee owners (banks).
(b) Value.	The approximage value of the land is from $15 to $25 per acre.	The average value of the land is from $10 to $20 per acre.

10. WORKS OF MAN.

No structures except small bridges have been built on the streams of either of the watersheds. No erosion control measures have been practiced on the watersheds.

11. AVAILABILITY OF RELIEF LABOR	WATERSHED Q	WATERSHED W"
	Table #3 (see Tables) giving the population of towns lying within a radius of 20 miles of Watershed Q, indicates that a total population of 33,162 can be drawn upon for relief labor. The towns of Newcomerstown, Coshocton, West Lafayette, Sugar Creek, Shanesville, Dover and New Philadelphia are all industrial centers and there are good reasons to believe that sufficient relief labor will be available. There are no important WPA or other projects located in the vicinity which would draw on the available relief labor supply.	Table #3 (see Tables) giving the population of towns lying within a radius of 20 miles of the Watershed W", indicates that a total population of 24,311 can be drawn upon for relief labor. The towns of Carrollton and Urichsville are industrial centers. However, WPA projects under way in the vicinity and the Muskingum Watershed Conservancy District dams will probably draw most of the available relief labor.

CONCLUSIONS

The analysis given in the preceding pages indicates that the watershed Q possesses considerable advantages over W". Of these, the most important ones are:

1. The symmetry of Q is nearly perfect, whereas that of W" is one to two, indicating that two-thirds of its area lies on one side of the major stream.
2. The soil on Q is more uniform and is 94.1% of the Muskingum Series, whereas only 83% of the soil on W" is of that series.
3. As far as the slope distribution is concerned, W" has a smaller absolute "percent deviation from the mean" than Q. However, the deviation for W" is negative, indicating that it is flatter than the average, whereas Q is somewhat steeper than the average. Considering that the selected watershed is to represent some of the steeper land in West Virginia as well as the rest of the land in the Region, it would seem that Watershed Q would be more representative.
4. The drainage characteristics of Q are much more satisfactory than those of W", the large number of small watersheds of W" notwithstanding. This is probably the deciding factor in the selection since the complexity of the drainage of W" would make the interpretation of the data obtained in the course of the studies very difficult to express correctly.

5. The availability of aerial prints on Q will greatly expedite the construction work connected with the establishment of the watershed. This and the proximity of industrial towns will make it possible to use Emergency Relief Funds and Relief Labor during the construction phase of the work on the watershed.

In view of the above, the selection of the watershed Q was recommended by Mr. C. E. Ramser and approved by Dr. W. C. Lowdermilk, Associate Chief of the Soil Conservation Service.

TESTIMONIES OF MEMBERS OF SALT CREEK PROJECT STAFF AND OTHER INTERESTED PERSONS RELATIVE TO THE CHARACTERISTICS OF THE INVESTIGATED EXPERIMENTAL WATERSHED SITES

* A. H. PASCHALL - CHIEF SOIL EXPERT

A	- Mining.
A'	- Small tracts of land along Route 40.
A"	- Not representative. Abandoned land to be considered.
B GROUP	- Consider.
C	- Difficult to obtain cooperation with farmers.
C'	- Some sandy soil, but consider.
C_1	- Sandy soil, but consider.
D GROUP	- Fair territory.
D"	- Real prospect. Good farming. Mixed limestone soil. No mining. Investigate.
E GROUP	- Different topography. Mixed soil. Do not consider.
F GROUP	- Discard because of mining.
G GROUP	- Discard because of mining.
H GROUP	- Soils mixed, Muskingum predominant. Possibility of some mining? Investigate.
I GROUP	- Steep territory. Not representative. Stony. Muskingum type of soil, but shallow 15 to 20 inches. Not recommended.
K GROUP	- Steep territory. Sandy soil? Not representative.
L GROUP	- Consider.
N GROUP	- Heavy shale soil. Not typical of region.
O GROUP	- Amish people.
P GROUP	- Amish people. Representative territory. Consider.
Q GROUP	- Consider.
Q"$_{L"}$	- Consider.
R GROUP	- Steep and sandy? Consider.

* See Page #2

* A. H. PASCHALL - CHIEF SOIL EXPERT

T GROUP - Possibility of different soils. Fire clay subsoil.

U, V & W GROUP - Consider.

w_2' & w_2 - Rather steep.

W GROUP - Poor roads.

4 GROUP - No objection.

9 GROUP - Topography, not typical.

CONCLUSION

Consider groups A, B, C, & D.

NOTE

Aerial photographs of Muskingum, Guernsy and Tuscarwas counties.

* Mr. Paschall, Chief Soil Expert, Soil Conservation Service, Project #14, Zanesville, Ohio, has been in charge of the mapping of the soils in the Salt Creek watershed.
Mr. Paschall previously resided in the State of Pennsylvania.

* W. B. OLIVER - SOIL EXPERT

A GROUP	-	Typical Muskingum soil. Typical agriculture.
A	-	Commercial mining to be investigated.
A'	-	Objection to Route 40, because of small tracts of land.
A"	-	Possibility of flint.
B GROUP	-	Investigate closely. Rock strata sloping southeast.
b GROUP	-	Backwater from the Muskingum river will probably cause plenty of trouble.
C GROUP	-	Typical agriculture, good roads.
C' & c_1	-	75% of people owners of their land. Investigate.
F GROUP	-	Poor class of people. Not representative of region. Not to be considered.
G GROUP	-	Commercial mining.
H GROUP	-	Not typical Muskingum soil (15%). Variable soil conditions on the order of poorly drained soil. Road conditions OK. Typical topography. Telephone OK. Consider.
I GROUP	-	Soils fairly representative with exception of ridge between I' & I". Slopes quite steep and massive sandstone layers. Slopes Muskingum loam. Topography steeper than general region. Slopes steeper than should be cultivated. Road conditions good.
I	-	Fairly representative of residual country. Consider.
I'	-	Not to be considered.
I"	-	Not to be considered.
i_1	-	Not to be considered.
K GROUP	-	Same as I". Not to be considered.
L & M GROUP	-	Representative of Muskingum soil. Otherwise no information.
N GROUP	-	Not typical because more bottom land. Slopes typical. Not to be considered.
n_4 GROUP	-	Investigate.
O GROUP	-	Investigate possibility of Amish people.

* See Page #2

* W. B. OLIVER - SOIL EXPERT

P & Q GROUP 8 & R	-	Representative of Muskingum soil. Otherwise no information.
S GROUP	-	Typical of Muskingum soil. Typical agriculture. Some commercial mining.
T GROUP	-	No information.
W_3	-	Resettling group considering purchase as a recreational and forest park. Submarginal land. Not typical agriculture. More Muskingum sand than loam.
W_2 W_2' W' & W	-	Typical Muskingum soil. No other information.
W_1 & W_1'	-	Investigate.
W",V & U GROUP	-	Average agriculture. Should investigate.
4 GROUP & 5 GROUP	-	Red shale soils not typical of Muskingum soils. Meigs, Upshur and Belmont soils. Farming not typical of Muskingum farming. Less cultivated land. Not to be considered.
6 & 7 GROUP	-	Submarginal land badly eroded. Poor type of farming. Not representative. Not to be considered.

* Mr. Oliver is Soil Expert under A. H. Paschall, Chief Soil Expert, and has been in charge of the mapping of the soils in the Muskingum Valley watershed.
Previous to working for the Soil Conservation Service, Project #14, Zanesville, Ohio, Mr. Oliver resided in the State of Pennsylvania.

NOTES TAKEN ON FIELD INSPECTION TRIPS
TO
PROPOSED EXPERIMENTAL WATERSHED SITES

BY

D. B. KRIMGOLD

RECONNAISSANCE SURVEY OF PROPOSED EXPERIMENTAL WATERSHED V
CARROLLTON QUADRANGLE - U. S. G. S.
BASE MAP
AUGUST 24, 1935

By

D. B. Krimgold

Notes recorded by G. L. Sherman

Weather: Fair and clear

North portion more rocky than average.

Rock outcrop shown along road.

Northeast corner of watershed more pasture than average, not typical.

The eastern central portion cleared more than average.

The eastern half of southern portion fairly typical farming.

D. B. Krimgold

(by inspection trip through territory)

I

OUT Too steep, stony and rocky in parts.
Not typical agriculture.
Meigs soils.
Large area of potential gas development.
Many slips.

H'

OUT Large percentage of abandoned land.
Considerable mining.
Not typical.

H

OUT Poor aspect distribution.
Not typical agriculture.
Meigs soils.
Poor shape.
Insufficient number of sub-drainages.

D. B. KRIMGOLD
(by inspection trip through territory)

Q - Fair gaging site. Typical country, good flow, not thickly populated. One mine in center of eastern ridge.

Q' - Half in Holmes County. Amish? Typical sandy on ridges, no mining, streams over-flow, good opportunity for timber unit. Sparsely populated in southwestern corner. Poor road. Plenty of labor can be used on road construction. Fair gaging sites available. Typical soils. Out ?

S - Good gaging site. Orchards, central portion cleared. Not quite enough timber.

S' - Orchards. U. S. Route #21 passes through the entire length of area. Good gaging possibilities. Good stream flow.

L - Typical. Deep soil on west ridge. Silt loam. Good gaging possibilities. Good site for timber units. Small portion sub-marginal. Good stream flow.

L' - Central ridge a little better than average farming, otherwise fairly typical. Good timber study possibilities in north-eastern end.

V - Typical farming and typical topography. Safe with respect to mining. Quite close to Carrollton. Located at headwaters of Indian Fork which drains into Atwood Dam Reservoir (M.C.D.)

W - Safe for mining, fair prospect, drains into south fork of McGuire Creek. (M.C.D.) Reservoirs.

W' - Fair prospect, typical country. Drains into north fork of McGuire Creek. (M.C.D.) Reservoirs.

w_1 & w_1' - Potential oil developments. Small areas. Fairly close to present purchase area, M.C.D. Good prospect for small check watersheds of either. Both drain into north portion of McGuire Creek.

w_1 - Possibility of mining in lower half.

m_1 - Watershed of main stream quite typical. A good possibility for small check area.

APPENDIX II

Selection of Experimental Watershed in the North Appalachian Region

TABLES

TABLE NO. 1

COMPARATIVE CHARACTERISTICS OF WATERSHEDS IN THE NORTH APPALACHIAN REGION

Watershed No.	Size and Shape: Area in Sq Mi	Area in Acres	Average Width x Length	Shape	Symmetry	Location: County	Township	USGS Quadrangle	Distance From: Nearest Town	S.C.S. Exp Sta.	Soils: Muskingum Series % of Total	Geology: Conditions	Topography: Range in Elevation	Slope Distribution: 0 to 12 %	12 to 20 %	20 % and up
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A	688	4403	17x40	bottle	1:2	Muskingum	Hopewell Springfield	Zanesville	Zanesville 7.0	3.0	92.0	Limited Mines	800-1100	1.9	24.2	63.8
A'	716	4582	23x325	rectangular	1:1	Muskingum	Falls-Hopewell	Zanesville	Zanesville 5.0	1.5	93.3	Satisfactory	760-1040	18.2	59.6	22.2
A''	458	2931	19x25	leaf	1:2	Muskingum	Hopewell	Zanesville	Zanesville 7.5	1.3	93.0	"	750-1050	25.6	8.5	65.9
B	364	2330	13x29	leaf	1:3	Muskingum	Licking	Frazeysburg	Frazeysburg 2.5	0.0	88.2	.	800-1000	21.8	22.2	56.0
B'	468	2995	16x30	fan	1:1	Muskingum	Cass	Frazeysburg	Dresden 2.5	10.5	87.8	.	800-1000	12.2	29.3	58.5
C	661	4230	22x32	leaf	1:2	Muskingum	Salem-Adams	Conesville	Conesville 8.5	16.0	100.0	Potential Coal Mining	950-1050	50.0	1.5	48.5
C'	686	4390	1.8x4.0	bottle	1:3	Muskingum	Salem Adams	Conesville	Conesville 6.5	16.0	100.0	.	800-1000	26.4	11.1	60.5
D	809	5178	21x38	rectangular	1:4	Muskingum	Union	Philo	New Concord 5	17.0	45.7	Satisfactory	800-1100	12.0	20.9	67.1
D'	594	3802	14x45	rectangular	1:3	Muskingum	Salt Creek Rich Hill	Philo Cumberland	New Concord 4	17.0	36.5	.	710-1100	9.6	37.9	52.5
D''	944	6041	34x25	rectangular	1:2	Muskingum Guernsey	Union Westland	Philo Cumberland	New Concord 3.0	21.0	81	.	840-1100	3.3	74.2	22.5
E	605	3872	16x40	leaf	1:2	Muskingum	Salt Creek Bluerock	Philo	Taylorsville 5.5	19.0	50.9	.	760-1000	14.7	31.9	53.4
E'	647	4141	20x35	bottle	1:1	Muskingum	Bluerock	Philo	Taylorsville 4.0	17.5	30.0	.	760-1100	4.2	15.6	80.2
E''	593	3795	20x30	fan	1:1	Muskingum	[illegible]	Philo Cumberland	Taylorsville 7.5	20.5	38.6	.	780-1000	3.0	58.3	38.7
F	58	3712	14x40	leaf	1:2	Muskingum Morgan	[illegible]-Brush Creek	Philo Zanesville	Roseville 6.5	16.0		Worked Out Mines	720-1100			.
F'	59	3776	14x43	oblong	1:2	Morgan	York-Deerfield	McConnelsville	Roseville 7.0	17.5		.	800-1120			
F''	30	1920	10x30	leaf	1:2	Morgan	York-Bloom	Philo McConnelsville	Roseville 8.0	18.0		.	700-1000			
G	28	1792	10x23	leaf	1:1	Morgan Muskingum	York-Clay	New Lexington	Crooksville 4.0	16.0		.	840-1160			
G'	27	1725	1.0x2.5	bottle	1:1	Morgan Perry	York-Clay	New Lexington	Crooksville 2.5	15.5		.	780-1100			
H	54	3456	20x27	leaf	1:1	Guernsey	Richland-Jackson	Cumberland	Cambridge 6.0	25.5	95.0	Oil and Gas	840-1050	5.0	26.6	68.4
H'	429	2746	14x33	leaf	1:2	Guernsey	Westland	Cumberland Cambridge	Cambridge 4.0	25.5	100.0	.	800-1060		26.3	73.7
I	978	6259	22x47	leaf	1:4	Guernsey Muskingum	Adams-Highland	Cambridge	New Concord 4.0	23.5	95.8	.	810-1160	5.4	28.6	66.0
I'	694	4442	17x44	oblong	1:1	Guernsey	Adams-Knox Cambridge	Cambridge	Cambridge 5.0	26.0	95.7	.	800-1100	4.3	33.0	62.7
I''	11 74	7514	25x52	fan	1:2	Guernsey Muskingum	Knox	Cambridge	Cambridge 7.5	25.0	97.4	.	790-1120	11.8	22.5	65.7
K	658	4211	23x28	leaf	1:1	Coshocton	Oxford-Wheeling	Cambridge	Newcomerstown 4.0	31.5	97.1	Satisfactory	780-1000	11.7	11.4	76.9
K'	854	5466	23x40	rectangular	1:3	Guernsey Tuscarawas	Oxford-Wheeling Washington	Cambridge Newcomerstown	Newcomerstown 3.5	35.0	93.9	"	800-1100	24.1	6.4	69.5
L	757	4845	19x40	rectangular	1:2	Coshocton Tuscarawas	Bucks-Crawford	Newcomerstown	Newcomerstown 11.0	37.5	99.2	.	820-1300	1.5	29.5	69.0
L'	611	3910	17x36	leaf	1:2	Coshocton Tuscarawas	Bucks-Adams	Newcomerstown	Newcomerstown 8.0	37.0	96.7	.	880-1140	12.2	63.8	24.0
L'-Q'	11.22	7181	28x40	fan	1:1	Holmes Coshocton	German-Crawford	Coshocton Newcomerstown	Coshocton 11.5	37.0	94.7	.	820-1220	26.0	11.3	62.7
M	10.72	6861	26x42	fan	1:1	Coshocton Tuscarawas	Bucks	Newcomerstown	Newcomerstown 7.5	39.5	92.4	"	820-1300	11.0	41.0	48.0
M'	710	4544	21x36	leaf	1:2	Tuscarawas	Bucks-Auburn	Newcomerstown	New Philadelphia 11.0	40.0	86.6	.	1020-1220	9.3	67.5	23.2
N	54	3456	15x37	leaf	1:2	Tuscarawas	Dover	Navarre	Dover 3.0	49.5		.	880-1200			
N'	68	4352	17x40	rectangular	1:3	Tuscarawas	Franklin	Navarre	Dover 5.5	50.5		.	820-1140			
N''	53	3392	16x33	leaf	1:1	Tuscarawas	Dover Sugar Creek	Navarre	Dover 5.0	49.0		.	840-1200			
O	52	3328	13x40	leaf	1:1	Holmes	[illegible]-Walnut Creek	Navarre Millersburg	Millersburg 9.0	46.5		.	1000-1300			
O'	33	2112	10x33	leaf	1:2	Holmes	Walnut Creek	Navarre	Millersburg 11.0	47.0		.	1000-1300			
P	40	2560	12x33	bottle	1:2	Holmes	German Walnut Creek	Navarre	Millersburg 10.0	43.5		.	1000-1260			
P'	29	1856	10x28	rectangular	1:1	Holmes	German	Navarre Millersburg	Millersburg 12.0	43.5		.	1000-1220			
Q	763	4883	15x52	leaf	1:1	Coshocton	Tiverton Crawford	Coshocton	Coshocton 8.5	34.5	94.1	.	820-1220	29.2	7.6	63.2
Q'	993	6355	22x48	rectangular	1:1	Coshocton	[illegible]	Coshocton	Millersburg 8.5	38.0	93.2	.	860-1220	39.4	53.0	7.6
R	5.19	3322	14x40	oblong	1:3	Coshocton	Mill Creek	Coshocton	Coshocton 8.5	33.0	94.7	.	800-1200	8.0	47.6	44.4
R'	604	3836	14x45	leaf	1:3	Coshocton	Bethlehem	Coshocton	Coshocton 7.5	32.0	98.2	Potential Coal Mining	800-1180	43.0	17.0	40.0
S	516	3302	12x45	leaf	1:1	Tuscarawas	Adams-Jefferson	Newcomerstown	Newcomerstown 5.5	40.0	87.4	.	820-1100	12.6	38.7	48.7
S'	643	4115	19x35	leaf	1:1	Tuscarawas	Jefferson	Newcomerstown	Newcomerstown 5.0	42.0	87.9	.	800-1200	30.0	21.0	49.0
T	90	5760	27x33	leaf	1:1	Jackson	Scioto-Franklin	Oak Hill-Jackson	Jackson 5.5	82.0		Satisfactory	700-900			
T'	38	2432	10x33	oblong	1:1	Jackson	Lick-Franklin	Oak Hill-Jackson	Jackson 2.5	85.0			630-880			
U	617	3949	19x34	rectangular	1:2	Carroll	Center Washington	Carrollton	Carrollton 4.0	72.0	87.5	"	1060-1300	34.4	44.7	20.9
U'	757	4845	18x43	fan	1:1	Carroll	Fox-Center Washington	Scroggsfield Carrollton	Carrollton 5.0	73.0	52.5	.	1060-1240	35.0	47.9	17.1
V	544	3482	17x32	leaf	1:1	Carroll	Center	Carrollton	Carrollton 2.0	71.0	87.5	.	1020-1300	21.9	36.4	41.7
V'	72	4608	19x38	leaf	1:2	Carroll	Lee-Washington	Carrollton Scroggsfield	Carrollton 4.5	72.0		.	1000-1260			
W	728	4659	20x36	rectangular	1:3	Carroll	Perry-Union	Carrollton	Carrollton 6.0	65.0	100.0	.	1020-1320	8.5	27.2	64.3
W'	174	1114	28x13	rectangular	1:1	Carroll	Perry-Loudon	Scotsville	Carrollton 8.0	63.0	93.6	.	1020-1300	16.1	9.2	74.7
W''	6.39	4090	17x40	leaf	1:2	Carroll	Lee-Union	Carrollton	Carrollton 4.0	67.0	83.0	.	1020-1300	6.0	49.4	44.6
b	151	966	08x18	rectangular	1:1	Muskingum	Muskingum	Dresden	Dresden 5.5	7.8		Strip Mining	700-1000			
b'	116	742	06x20	triangular	1:2	Muskingum	Muskingum	Frazeysburg	Dresden 4.0	9.0		.	700-1000			
c	4.26	2726	15x31	rectangular	1:2	Muskingum	Highland	Conesville	Conesville 11.0	20.0	88.8	Potential Coal Mining	800-1050	21.1	15.9	63.0
l	2.0	1280	10x25	oblong	1:1	Guernsey	Adams-Cambridge	Cambridge	Cambridge 3.0	26.5	92.5	Oil and Gas	800-1000	7.5	27.5	65.0
m	264	1690	125x20	fan	1:2	Tuscarawas	Auburn-Bucks	Newcomerstown	New Philadelphia 10.0	42.0	97.0	Satisfactory	1020-1300	3.6	26.5	70.4
m_1	1.56	998	10x15	fan	1:1	Tuscarawas	Auburn	Newcomerstown	New Philadelphia 8.5	43.0	99.4	.	1020-1300	0.6	37.2	62.2
m_2	3.51	2246	12x30	leaf	1:2	Tuscarawas	Auburn Sugar Creek	Navarre	New Philadelphia 7.5	46.0	85.3	.	1000-1280	14.2	85.8	
n	23	1472	11x20	leaf	1:1	Tuscarawas	Dover-Sugar Creek	Newcomerstown	Dover 5.0	47.0		.	920-1240			
n_1	16	1024	072x22	oblong	1:1	Tuscarawas	Sugar Creek	Newcomerstown	Dover 4.5	48.0		.	920-1240			
n_2	29	1856	10x27	leaf	1:1	Tuscarawas	Dover-Franklin	Navarre	Dover 3.0	51.0		.	900-1240			
n_3	233	1491	10x25	leaf	1:1	Tuscarawas	Dover	Dover	Dover 2.5	54.5	99.6	.	880-1040	3.9	38.2	57.9
n_4	321	2054	25x14	fan	1:1	Tuscarawas	Dover-Lawrence	Dover	Dover 3.0	55.0	91.3	.	920-1180	8.7	34.6	56.7
w_1	169	1082	08x21	leaf	1:1	Carroll	Union	Carrollton	Carrollton 3.0	65.0	58.5	Oil and Mining	1080-1260	34.8	11.8	53.4
w_2	568	3635	10x18	rectangular	1:1	Carroll	Union	Carrollton	Carrollton 3.5	65.0	98.8	.	980-1220	33.4	5.5	61.1
w_3	342	2189	12x3.0	leaf	1:2	Carroll	Perry	Scotsville	Carrollton 8.5	61.0	100.0	Oil and Gas	1000-1280	9.9	24.9	65.2
w_4	306	1958	1.0x3.0	oblong	1:1	Carroll-Harrison	Perry-North	Sciotoville	Carrollton 9.5	59.0	99.3	.	980-1220	29.7	3.6	66.7
w_5	328	2099	11x30	leaf	1:3	Carroll	Union-Perry Monroe	Scotsville Carrollton	Carrollton 7.0	61.0	100.0	Satisfactory	960-1300		36.3	63.7
1	5.07	3245	12x45	rectangular	1:1	Coshocton	Jackson-Virginia	Conesville	Conesville Coshocton 6.0	20.0	93.4	Coal Mines	800-1100	12.9	22.3	64.7
2	293	1875	10x23	oblong	1:3	Coshocton	Jackson-Virginia	Conesville	Conesville Coshocton 5.0	20.0	100.0	.	820-1100		28.7	71.3
3	463	2963	11x45	oblong	1:2	Coshocton	Jackson-Virginia	Conesville	Conesville Coshocton 4.5	20.5	92.8	.	800-1110	7.1	22.2	70.7
4	208	1843	1.0x3.0	oblong	1:2	Guernsey	Center-Wills	Antrim	Washington [illegible]	36.0	25.7	Satisfactory	840-1080	17.9	65.0	17.1
4'	264	1683	1.2x2.2	fan	1:1	Guernsey	Wills	Antrim	Washington 4.0	35.0		.	840-1060	7.2	7.2	85.6
4''	237	516	10x26	rectangular	1:1	Guernsey	Wills	Antrim Fairview	Washington 4.0	40.0		.	860-1120	16.0	36.3	47.7
5	27	1728	07x33	rectangular	1:2	Guernsey	Wills-Madison	Antrim	Washington 8.0	42.0		.	820-1000	17.4	31.1	51.5
5'	284	1818	11x26	rectangular	1:1	Guernsey	Madison	Antrim	Washington 7.5	41.0		.	820-1000	22.8	13.0	64.2
6	118	755	06x20	oblong	1:1	Guernsey	Madison	Antrim	Cambridge 11.0	39.0	61.0	.	840-1000		4.2	95.8
6'	107	685	1.0x19	oblong	1:2	Guernsey	Madison-Jefferson	Antrim	Cambridge 10.5	38.0	100.0	.	820-1020		100.0	
7	081	518	06x16	oblong	1:1	Guernsey	Jefferson	Antrim	Cambridge 10.0	37.0	100.0	.	820-1020		36.0	64.0
7'	093	595	045x20	oblong	1:1	Guernsey	Jefferson	Antrim	Cambridge 9.0	36.5	100.0	.	820-1100		32.0	68.0
8	42	2688	082x50	oblong	1:1	Holmes Tuscarawas	Rush-German Sugar Creek	Newcomerstown	Dover 10.0	42.0		.	1000-1280			
9	33	2112	11x30	rectangular	1:2	Holmes Tuscarawas	Walnut Creek Sugar Creek	Navarre	Dover 9.5	46.0		.	1000-1240			
10	03	192	03x10	oblong	1:1	Carroll	Lee	Salineville	Bergholz 5.0	67.0		Coal Mining	1000-1200			
10'	03	192	03x12	oblong	1:1	Carroll	Lee	Salineville	Bergholz 5.5	67.0		.	1000-1240			
11	08	512	13x17	oblong	1:1	Carroll	Lee	Summitville Carrollton	Bergholz 5.5	66.0		.	1000-1300			

Watershed No.	Drainage Characteristics: Principal Stream Name	Tributary To –	Number of Intermediate Watersheds	Aspect %	Vegetative Cover: Timber %	Grass Lands %	Crops %	Bench Marks Per Sq Mile	Facilities Available: Roads	Electricity	Telephone	Gaging Sites	Land: Approx Av Value Per Acre	Works of Man	Reason for Elimination
1	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
A	Thompson Run	Jonathan Ck	8	60NE-40SW	16	63	21	073	Good — Gravel	Available	Available	Poor	$40-50	Check Dams-Mines	Heavy Commercial Mining
A'	Timber Run	Licking River	13	40N-60S	7	72	21	182	US 40, Good Gravel	.	.	.	.	.	Thickly Populated-Suburban
A''	Unnamed	Poverty Run	12	30N-40SE-30NW	22	53	25	112	Poor	not available	not available	.	10-20		Sub Marginal-not typical
B	Stump Run	Licking River	7	25W-30NE-45SW	6	69	25	2.0					20		Peculiar Topography
B'	Big Run	Licking River	9	[illegible]	6	71	23	125					.		Affecting Precipitation
C	Prairie Fork	Salt Creek	12	20E-70S-30N-30W	18	38	44	014	Fair	not available			20-30	Check Dams	Richest Potential Coal Field in Ohio
C'	Symmes Ck	Muskingum Riv	8	20E-20S-30W-30N	17	46	37	13	.	.			.		.
D	White Eyes Ck	Salt Creek	10	[illegible]	15	56	29	16	.	.	not available	Fair	20	.	[illegible] - Soil not Typical
D'	Williams Fork	Buffalo Fork	8	25N-25E-30W-20S	7	67	26	1.0	.	.	.	.	.	.	Considerable Erosion Control Work
D''	Crooked Creek	Wills Run	11	[illegible]	6	71	23	035	.	.	.	.	.	.	Soil Not Typical of Region
E	Kent Run	Salt Creek	17	[illegible]	13	58	29	1.5	Poor	.	.	.	15-20	.	.
E'	Manns Fork	Salt Creek	11	20N-20S-30W-30E	10	73	17	062	.	.	.	.	10-20	.	.
E''	Buffalo Fork	Salt Creek	11	[illegible]	14	62	24	12	.	.	.	.	15-20	.	.
F	Blue Rock Creek	Muskingum River	13	20E-20W-30N-30S				1.2							Worked out Commercial Coal Mines
F'	Unnamed	[illegible] Run	7	[illegible]				15							.
F''	Big Bottom Run	Muskingum River	7	20E-20W-30N-30S				13							.
G	Unnamed	Black Fork	6	[illegible]				13							.
G'	Dry Run	Black Fork	7	[illegible]				1.0							.
H	Chapman Run	Wills Creek	7	20E-10W-35N-35S	7	74	19	1.3	Fair	not available	not available	Poor	15-20		Land Use Not Typical
H'	Crooked Creek	Wills Creek	4	[illegible]	7	75	18	1.0	.	.	.	.	.		.
I	Peters Creek	Crooked Creek	17	30E-30W-20N-20S	20	54	26	0.8	.	From Cambridge	From Cambridge	Fair	15-25		Topography Too Steep Landslides
I'	Sarchet Run	Salt Creek	14	[illegible]	22	52	26	0.8	.	.	.	.	.		.
I''	Indian Camp Run	Wills Creek	18	[illegible]	35	46	19	1.1	.	.	.	.	.		.
K	Unnamed	Wills Creek	9	[illegible]	28	48	24	10							Worked out Commercial Coal Mines
K'	Postboy Creek	Birds Run	12	[illegible]	29	43	28	12							Topography not Typical
L	White Eyes Creek	Tuscarawas Riv	12	20N-20S-30E-30W	18	50	32	0.9	Ohio 93 - Poor, Secondary	From Baltic or Sugar Creek	available	Good	15-20		[illegible]
L'	East Fork	Tuscarawas Riv	9	30N-30S-30W-10E	10	41	49	12	Gravel, Main - Poor Secondary		.	.	.		Potential Coal Mining (State Geologist Report)
L'-Q'	West Fork Creek	White Eyes Cr	16	30E-30W-20N-20S	22	41	37	09	Fair		.		20-30		Too thickly populated
M	Evans Creek	Tuscarawas Riv	17	[illegible]				10	Good				.		Peculiar Shape
M'	East Branch	SF Sugar Creek	11	30N-30S-20E-20W	4	43	53	05	.			Poor	.		Poor Gaging Sites-Amish Element
N	[illegible] Ck	Sugar Creek	12	[illegible]				04							
N'	Broad Run	Sugar Creek	12	[illegible]				13							
N''	Unnamed	Broad Run	12	[illegible]				13							Area lies within the Amish
O	Goose Creek	Walnut Creek	6	[illegible]				08							Settlement. Possibility of
O'	Unnamed	Walnut Creek	7	[illegible]				12							cooperative agreements precludes
P	Walnut Creek	SF Sugar Creek	4	[illegible]				10							
P'	Troyer Valley Ck	Sugar Creek	6	[illegible]				10							
Q	Little Mill Ck	Mill Creek	19	[illegible]	9	46	45	12	Gravel, Main - Poor Secondary	From Keene or Coshocton	From Keene	Good	15-25		
Q'	Mill Creek	Walhonding Riv	21	[illegible]	13	40	47	086				Fair	20-30		Topography not Typical
R	Turkey Run	Mill Creek	11	[illegible]	13	43	44	1.0	Good						Poor Symmetry
R'	Bucklew Run	Killbuck Ck	9	[illegible]	24	39	37	11	.						Rocky Outcrops and Stoney Soil
S	NF Buckhorn Ck	Buckhorn Ck	12	[illegible]	18	44	38	1.1	.						Potential Coal Mining Development
S'	Buckhorn Ck	Tuscarawas R	18	[illegible]	13	47	39	085	.						
T	Four Mile Ck	Salt Creek	18	[illegible]				08							Mining - Not Typical Farming
T'	Unnamed	Salt Creek	11	[illegible]				08							
U	Pipes Fork	Still Fork	11	[illegible]	10	36	54	092	Poor			Poor			Poor Gaging Sites Flat Bottoms
U'	Friday Ck	Still Fork	21	[illegible]	6	43	51	063	.						Poor Gaging Sites Flat Bottoms
V	Gant Creek	Indian Fork	16	[illegible]	14	45	41	055	Fair						Peculiar Shape
V'	Center Fork	Elk Horn Ck	17	[illegible]				070							Sub Marginal-Not Typical Farming
W	McGuire Ck	Conotton Ck	13	[illegible]	19	52	29	041	Gravel, Main - Poor Secondary	From Carrollton or Harlem Springs	available	Good	10-20		Symmetry - Complex Drainage
W'	Dining Fork	Conotton Ck	22	[illegible]	24	40	36	033	.	.					Oil and Gas - Symmetry
W''	NF McGuire Ck	Conotton Ck	12	[illegible]	22	41	37	100	.	.	available	Fair	10-20		Symmetry - Complex and Irregular Drainage
b	Blunt Run	Muskingum Riv		50NE-50SW				15							Stripe Mining and Size
b'	Beech Run	Muskingum Riv		[illegible]				06							
c	White Eyes Ck	Wills Creek		[illegible]	29	46	25	1.0							Same as 'C'
l	Unnamed	Crooked Ck		[illegible]	23	55	22	1.5							Topography Too Steep
m	Unnamed	East Branch		[illegible]	12	44	44	04							
m_1	Unnamed	East Branch		[illegible]	15	33	52	2.0							
m_2	Unnamed	East Branch		[illegible]	13	39	48	1.0							
n	Crooked Ck	Stone Creek		[illegible]				05							Same as M group also Size
n_1	Unnamed	Crooked Ck		[illegible]				1.5							
n_2	Unnamed	Sugar Creek		[illegible]				013							
n_3	Unnamed	Tuscarawas R		20N-20S-30E-30W	6	43	51	09							
n_4	Unnamed	Sugar Creek		[illegible]	10	44	46	1.1	.						
w_1	Unnamed	NF McGuire Ck		[illegible]	22	44	34	1.0							Gas-Oil-Coal Mining Size
w_2	Bear Hole Run	NF McGuire Ck		[illegible]	16	54	30	1.0							
w_3	Kirby Run	Dining Fork		[illegible]	13	59	28	1.0							
w_4	Scott Run	Conotton Ck		[illegible]	2	54	44	1.0							
w_5	Unnamed	McGuire Ck		[illegible]	37	44	19	03						Leesville Dam-normal Pool	Within normal Pool of Leesville Dam
1	Moscow Brook	Mill Fork		[illegible]	13	59	28	054							Coal Mining and Too Steep
2	Unnamed	Mill Fork		[illegible]	10	66	24	1.0							
3	Mill Fork	Wakatomika Ck		[illegible]	10	64	26	10							
4	Hawkins Run	Leatherwood Ck		[illegible]	22	39	38	13							Soils not Typical of Region
4'	Infirmary Run	Leatherwood Ck		[illegible]	13	55	32	067							
4''	Unnamed	Leatherwood Ck		[illegible]	18	55	27	17							
5	Unnamed	Salt Fork		[illegible]	10	56	34	10							Soils not Typical of Region
5'	Unnamed	Salt Fork		[illegible]	22	51	27	1.0							
6	Christian Ck	Brushy Fork		50E-5W	28	50	22	10				Poor			Topography-Drainage-Size
6'	Unnamed	Brushy Fork		50E-50W	10	60	10	2.0				.			.
7	Unnamed	Brushy Fork		50E-50W	2	63	35	21				.			.
7'	Unnamed	Salt Fork		50E-50W	7	73	20	1.0				.			.
8	Pleasant Valley Ck	East Branch		[illegible]				07							Amish Element
9	Unnamed	SF Sugar Creek		[illegible]				1.2							
10	Unnamed	Elk Horn		50NE-50SW											Coal Mining and Size
10'	Unnamed	Elk Horn		50NE-50SW											
11	Unnamed	Elk Horn		50NE-50SW				1.0							

EXPLANATORY NOTES:

Col 4 - Average width was obtained by dividing the area into the length of the watershed.

Col 5 - Watersheds narrow at headwaters widening out in the middle and narrowing down at the discharge end were designated as "leaf".

Col 6 - The symmetry is expressed as a ratio of the area lying on one side of the principal stream to the area lying on the opposite side.

Cols. 10 & 11 - Distances are given in miles.

* Watersheds on which detailed reconnaissance surveys were made.

STUDY OF SLOPE DISTRIBUTION AND LAND USE ON PROPOSED EXPERIMENTAL WATERSHEDS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
		SLOPE DISTRIBUTION												LAND USE											
		0 TO 12%				12 TO 20%				20% AND UP				TIMBER				GRASSLANDS				CROPS			
WATERSHED No.	AREA IN ACRES	ACRES	PERCENT OF TOTAL	DISCREP. %	% DEV. FROM MEAN	ACRES	PERCENT OF TOTAL	DISCREP %	% DEV FROM MEAN	ACRES	PERCENT OF TOTAL	DISCREP %	% DEV FROM MEAN	ACRES	PERCENT OF TOTAL	DISCREP %	% DEV FROM MEAN	ACRES	PERCENT OF TOTAL	DISCREP %	% DEV FROM MEAN	ACRES	PERCENT OF TOTAL	DISCREP %	% DEV FROM MEAN
A	4403	524	11.9	-4.4	27	1070	24.5	-7.0	22	2809	63.8	+11.4	22	704	16	+0.3	2	2774	63	+11.2	22	925	21	-1.5	35
A'	4582	834	18.2	+1.9	12	2731	59.6	+28.3	91	1017	22.2	-30.2	58	321	7	-8.7	55	3299	72	+20.2	39	962	21	-11.5	35
A'	2931	750	25.6	+9.3	57	249	8.5	-22.8	73	1932	65.9	+13.5	26	645	22	+6.5	40	1553	53	+1.2	2	733	25	-7.5	23
B	2330	508	21.8	+5.5	34	517	22.2	-9.1	29	1305	56.0	+15.6	7	140	6	-9.7	62	1608	69	+17.2	33	582	25	-7.5	23
B'	2995	365	12.2	-4.1	25	878	29.3	-2.0	6	1752	58.5	+16.1	12	180	6	-9.7	62	2126	71	+19.2	37	689	23	-9.5	29
C	4230	2115	50.0	+33.7	207	63	1.5	-29.8	95	2052	48.5	-3.9	7	761	18	+2.3	15	1607	38	-13.8	27	1862	44	+11.5	35
C'	4399	1247	28.4	+12.1	74	487	11.1	-20.2	65	2656	60.5	+8.1	15	746	17	+1.3	8	2019	46	-5.8	11	1625	37	+4.5	14
C₁	2726	575	21.1	+4.8	29	433	15.9	-15.4	49	1718	63.0	+10.6	20	791	29	+13.3	85	1253	46	-5.8	11	682	25	-7.5	23
D	5178	621	12.0	-4.3	26	1082	20.9	-10.4	33	3475	67.1	+14.7	28	777	15	-0.7	5	2894	56	+4.2	8	1502	29	-3.5	11
D'	3802	365	9.6	-6.7	41	1441	37.9	+6.6	21	1996	52.5	+0.1	0.5	266	7	-8.7	55	2547	67	+15.2	29	989	26	-6.5	20
D'	6041	199	3.3	-13.0	80	4483	74.2	+42.9	137	1359	22.5	+29.9	57	362	6	-9.7	62	4280	71	+19.2	37	1389	23	-9.5	29
E	3872	569	14.7	-1.6	10	1235	31.9	+0.6	2	2068	53.4	+1.0	5	542	14	-1.7	11	2246	58	+6.2	12	1084	28	-4.5	14
E'	4141	175	4.2	-12.1	74	646	15.6	-15.7	50	3321	80.2	+27.8	53	414	10	-5.7	36	3023	73	+21.2	41	704	17	-15.5	48
E'	3795	114	3.0	-13.3	82	2213	58.3	+27.0	86	1468	38.7	-13.7	26	531	14	-1.7	11	2353	67	+10.2	20	911	24	-8.5	26
H	3456	173	5.0	-11.3	69	919	26.6	-4.7	15	2364	68.4	+16.0	31	242	7	-8.7	55	2557	74	+22.2	43	657	19	-13.5	42
H'	2746	–		-16.3	100	722	26.3	-5.0	16	2024	73.7	+21.3	41	192	7	-8.7	55	2060	75	+23.2	45	494	18	-14.5	45
I	6259	337	5.4	-10.9	67	1790	28.6	-2.7	9	4132	66.0	+13.6	26	1252	20	+4.5	27	3380	54	+2.2	4	1627	26	-6.5	20
I'	4442	191	4.3	-12.0	74	1466	33.0	+1.7	5	2785	62.7	+10.3	20	977	22	+6.3	40	2310	52	+0.2	0.4	1155	26	-6.5	20
I'	7514	886	11.8	-4.5	28	1691	22.5	-8.8	28	4937	65.7	+13.3	25	2630	35	+19.3	123	3456	46	-5.8	11	1428	19	-13.5	42
I₁	1280	96	7.5	-8.8	54	352	27.5	-3.8	2	832	65.0	+12.6	24	294	23	+7.3	47	704	53	+3.2	6	282	22	-10.5	32
K	4211	493	11.7	-4.6	28	480	11.4	-19.9	64	3238	76.9	+24.5	47	1179	28	+12.3	78	2021	48	-3.8	7	1911	24	-8.5	26
K'	5466	1317	21.4	+7.8	48	350	6.4	-24.9	80	3799	69.5	+17.1	33	1585	29	+13.3	85	2350	43	-8.8	7	1531	28	-4.5	14
L	4845	72	1.5	-14.8	91	1429	29.5	-1.8	6	3344	69.0	+16.6	32	872	18	+2.3	15	2423	50	-1.8	14	1550	32	-0.5	2
L'	3910	477	12.2	-4.1	25	2495	63.8	+32.5	104	938	24.0	-28.4	54	391	10	-5.7	36	1603	41	-10.8	21	1916	49	+16.5	50
M	6861	754	11.0	-5.3	32	2813	41.0	+9.7	31	3294	48.0	-4.4	8	–	–	–	–	–	–	–	–	–	–	–	–
M'	4544	423	9.3	-7.0	43	3067	67.5	+36.2	116	1054	23.2	-29.2	56	182	4	-11.7	75	1954	43	-8.8	17	2408	53	+20.5	63
Q'	6355	2504	39.4	+23.1	141	3368	53.0	+21.7	69	483	7.6	-44.8	86	826	13	-2.7	17	2542	40	-11.8	23	2987	47	+14.5	45
Q	4883	1426	29.2	+12.9	79	371	7.6	-23.7	76	3086	63.2	+10.8	21	439	9	-6.7	43	2247	46	-5.8	11	2197	45	+12.5	38
Q-L'	7181	1867	26.0	+9.7	59	811	11.3	-20.0	64	4053	62.7	+10.3	20	1580	22	+6.3	40	2944	41	-0.8	21	2657	37	+4.5	14
R	3322	266	8.0	-8.3	51	1581	47.6	+16.3	52	1475	44.4	-8.0	15	432	13	-2.7	17	1428	43	-8.8	17	1462	44	+11.5	35
R'	3836	1633	43.0	+26.2	63	657	17.0	-14.3	46	1546	40.0	-12.4	24	928	24	+8.3	53	1508	39	-12.8	25	1430	37	+4.5	35
S	3302	416	12.6	-3.7	22	1278	38.7	+7.4	24	1608	48.7	-13.7	7	594	18	+2.3	15	1453	44	-7.8	15	1255	38	+5.5	17
S'	4115	1235	30.0	+13.7	84	864	21.0	-10.3	33	2016	49.0	-3.4	6	535	13	-2.7	17	1975	48	-3.8	7	1605	39	+6.5	20
U	3949	1358	34.4	+18.1	111	1766	44.7	+13.4	43	825	20.9	-31.5	60	395	10	-5.7	36	1422	36	-15.8	30	2132	54	+21.5	66
U'	4845	1695	35.0	+18.7	114	2322	47.9	+16.6	53	828	17.1	-35.3	67	291	6	-9.7	62	2083	43	-8.8	17	2471	51	+18.5	57
V	3482	767	21.9	+5.6	34	1267	36.4	+5.1	16	1453	41.7	-10.7	20	487	14	-1.7	11	1567	45	-6.8	13	1428	41	+8.5	26
W	4659	396	8.5	-7.8	48	1267	27.2	-4.1	13	2996	64.3	+11.9	23	885	19	+3.3	21	2425	52	+0.2	0.4	1351	29	-3.5	11
W'	1114	179	16.1	-0.2	1	102	9.2	-22.1	71	833	74.7	+22.3	43	267	24	+8.3	53	446	40	-11.8	23	401	36	+3.5	11
W'	4090	245	6.0	-10.3	63	2020	49.4	+18.1	58	1825	44.6	-7.8	15	900	22	+6.3	40	677	41	-10.8	21	1513	37	+4.5	14
m₁	1690	52	3.1	-13.2	81	448	26.5	-4.8	15	1190	70.4	+18.0	34	203	12	-3.7	24	744	44	-7.8	5	743	44	+11.5	35
m₂	998	6	0.6	-15.7	96	371	37.2	+5.9	19	621	62.2	+9.8	19	150	15	-0.7	5	329	33	-18.8	36	519	52	+19.5	60
m₃	2246	519	14.2	-2.1	13	1927	85.8	+54.5	174	–	–	-52.4	100	292	13	-2.7	17	876	39	-12.8	25	1078	48	+15.5	48
n₁	1491	58	3.9	-12.4	76	570	38.2	+6.9	22	863	57.9	+5.5	10	89	6	-9.7	62	641	43	-8.8	17	761	51	+18.5	57
n₂	2054	179	8.7	-7.6	46	711	34.6	+3.3	11	1164	56.7	+4.3	8	205	10	-5.7	36	904	44	-7.8	15	945	46	+13.5	42
w₁	1082	376	34.8	+18.5	113	128	11.8	-19.5	62	578	53.4	+1.0	5	238	22	+6.3	40	476	44	-7.8	15	368	34	+1.5	5
w₁'	3635	1214	33.4	+17.1	105	200	5.5	-25.8	82	222	61.1	+8.7	17	582	16	+0.3	2	1962	54	+2.2	4	1091	30	-2.5	[illegible]
w₂	2189	217	9.9	-6.4	39	545	24.9	-6.4	20	1427	65.2	+12.8	24	285	13	-2.7	17	1291	59	+7.2	14	613	28	-4.5	14
w₂'	1958	362	29.7	+13.4	82	70	3.6	-27.7	88	1306	66.7	+14.3	27	39	2	-13.7	87	1057	54	+2.2	4	862	44	+11.5	35
w₃	2099	–	–	-16.3	101	762	36.3	+5.0	16	1337	63.7	+11.3	22	777	37	+21.5	135	923	44	-7.8	15	399	19	-13.5	42
1	3245	418	12.9	-3.4	21	724	22.3	-9.0	29	2103	64.8	+12.4	24	422	13	-2.7	17	1914	59	+7.2	14	909	28	-4.5	14
2	1875	–	–	-16.3	100	538	28.7	-2.6	8	1337	71.3	+18.9	36	188	10	-5.7	36	1237	66	+14.2	27	450	24	-8.5	26
3	2963	210	7.1	-9.2	57	658	22.2	-9.1	29	2095	70.7	+18.3	35	296	10	-5.7	36	1896	64	+12.2	24	771	26	-6.5	20
4	1843	330	17.9	+1.6	10	[illegible]	65.0	[illegible]	107	315	17.1	-35.3	67	405	22	+6.3	40	719	39	-12.8	25	719	39	+6.5	20
4'	1683	121	7.2	-9.1	56	121	7.2	-24.1	77	1441	85.6	+33.2	63	219	13	-2.7	17	925	55	+3.2	6	539	32	-0.5	2
4'	1516	242	16.0	-0.3	1	550	[illegible]	+5.0	[illegible]	724	[illegible]	-4.7	9	273	18	+2.3	15	834	55	+3.2	6	409	27	+5.5	17
5	1728	301	17.4	+1.1	7	537	31.1	-0.2	1	890	51.5	-0.9	2	173	10	-5.7	36	967	56	+4.2	8	588	34	+1.5	5
5'	1818	414	22.8	+6.5	40	236	13.0	-18.3	58	1168	64.2	+11.8	23	400	22	+6.3	40	927	51	-0.8	2	491	27	-5.5	17
6	755	–	–	-16.3	100	32	4.2	-27.1	87	723	95.8	+43.4	83	211	28	+12.3	78	378	50	-1.8	4	166	22	-10.5	32
6'	685	–	–	-16.3	100	685	100.0	+68.7	220	–	–	-52.4	100	68	10	-5.7	36	548	80	+28.2	54	69	10	-22.5	69
7	518	–	–	-16.3	100	186	36.0	+4.7	15	332	64.0	+11.6	22	10	2	-13.7	87	327	63	+11.2	22	81	35	+2.5	8
7'	595	–	–	-16.3	100	190	32.0	+0.7	2	405	68.0	+15.6	30	42	7	-8.7	55	434	73	+21.2	41	119	20	-12.5	38
TOTALS	204,780	33,200				64,163				107,386				31,10[illegible]				102,2[illegible]4				64,377			
PERCENT		16.3				31.3				52.4				15.7				51.8				32.5			

NOTE. Discrepancy percent in each column for each individual watershed equals percent of total for that watershed minus the percent of total for the entire column.
Thus, discrepancy percent in slopes 0-12% for watershed A = 11.9 - 16.3 = -4.4.

Percent deviation from mean for each individual watershed equals $\frac{\text{Discrepancy percent for individual watershed} \times 100}{\text{Percent of total in column}}$

4.4×100 = 27%

TABLE NO. 3

DISTANCES TO AND POPULATIONS OF TOWNS
(above 500 population)

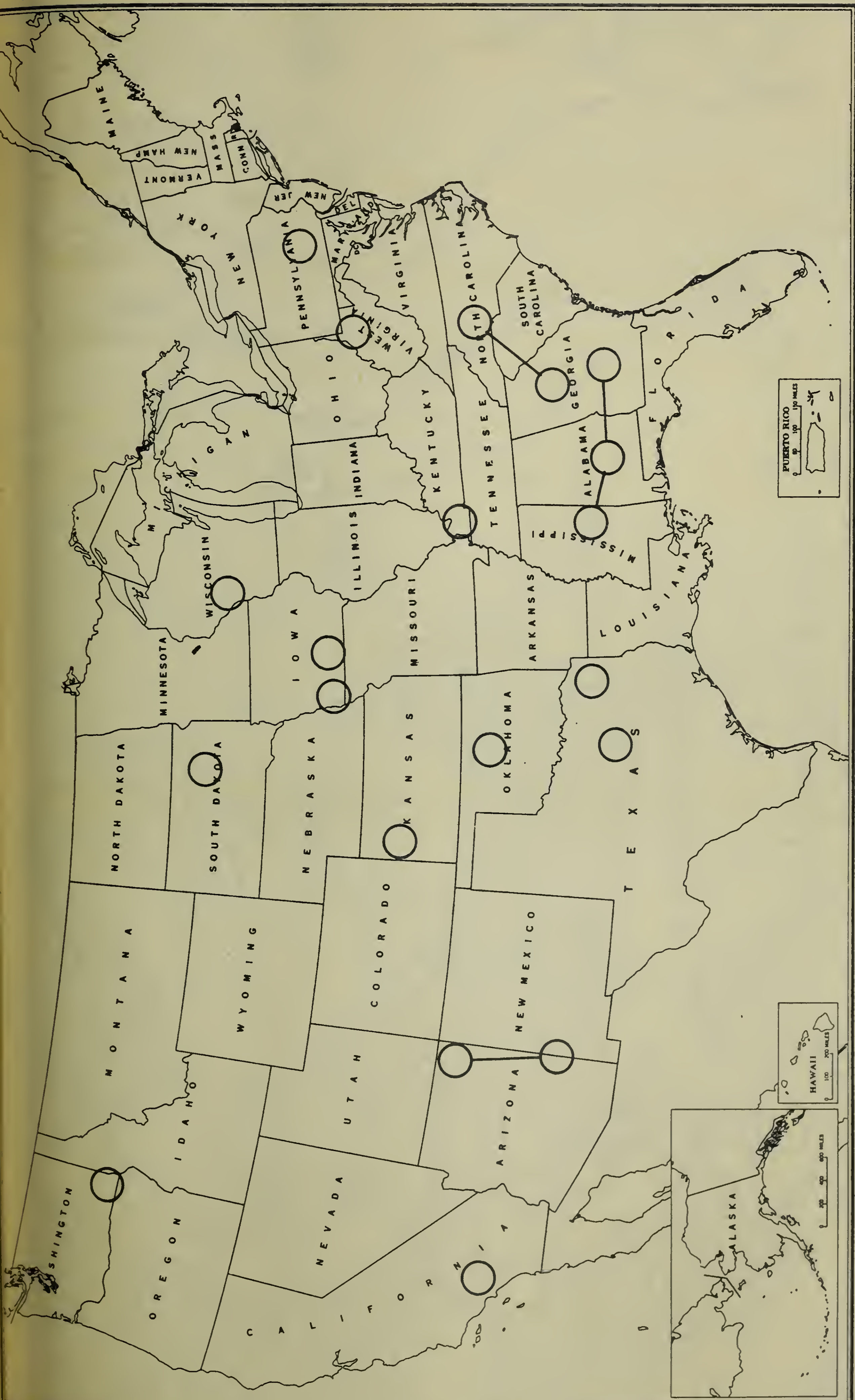
LYING WITHIN A TWENTY MILE RADIUS OF WATERSHEDS Q AND W"

Watershed Q			Watershed W"		
Name of Town	Popu-lation	Dis-tance	Name of Town	Popu-lation	Dis-tance
Dover and New Philadelphia	22,081	20 mi.	Carrollton	2,286	4 mi.
Killbuck	703	12 "	Salineville ...	2,133	13.5 "
Sugarcreek and Shanesville	1,389	12.5 "	Malvern	1,100	13.5 "
Baltic	545	7 "	Minerva	2,675	14.5 "
Newcomerstown	4,265	14 "	Scio	760	9.5 "
West Lafayette	1,106	8.5 "	Bergholz	918	9 "
Millersburg	2,203	13 "	Jewett	876	11.5 "
Gnadenhutten	870	20 "	Cadiz	2,597	16 "
Coshocton	10,500	8 "	Uhrichsville and Dennison ..	10,966	19 "
TOTAL	43,662		TOTAL	24,311	

FIGURES

Appendix II

Selection of Experimental Watershed in Northern Appalachian Region



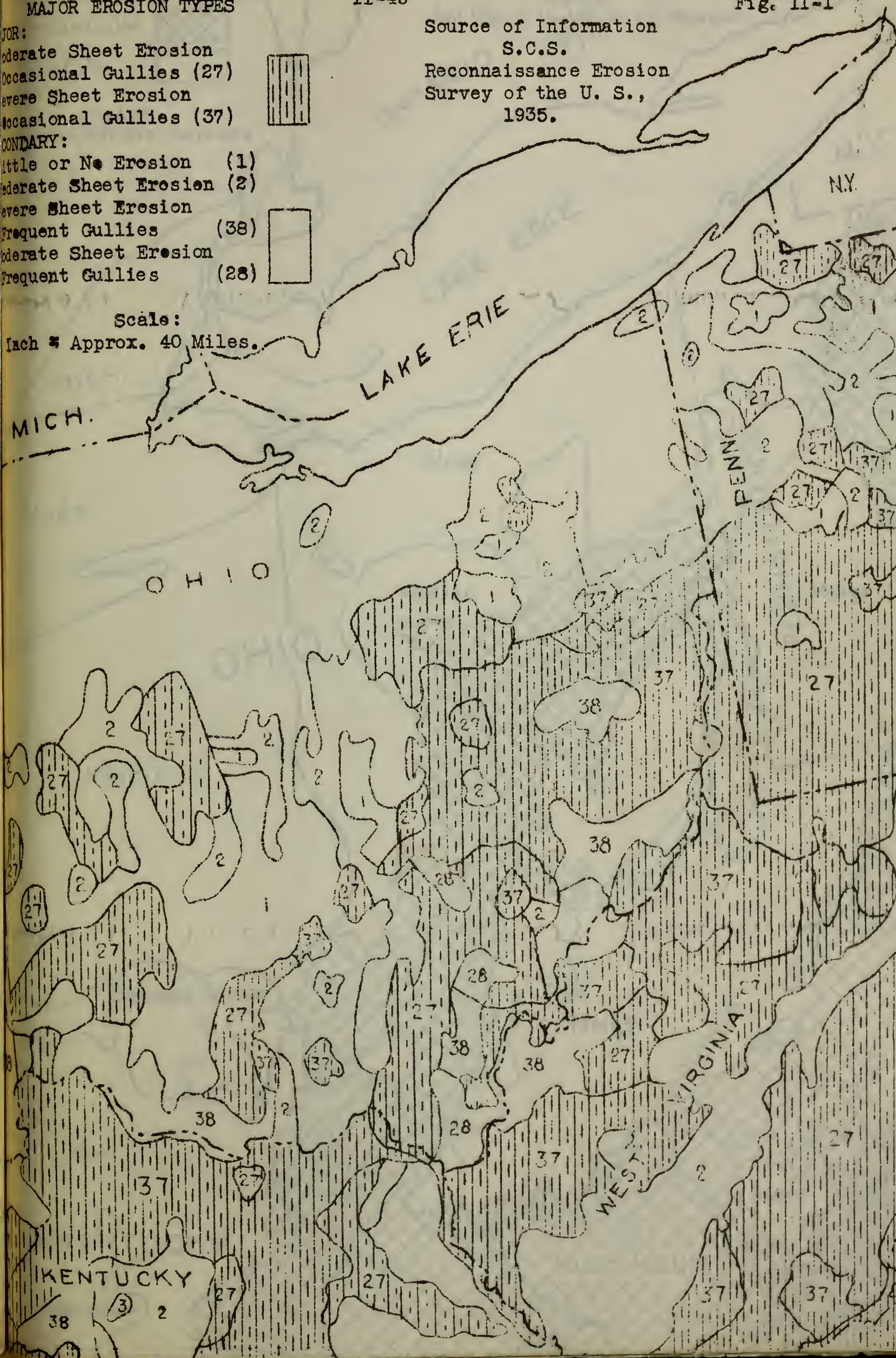
LEGEND

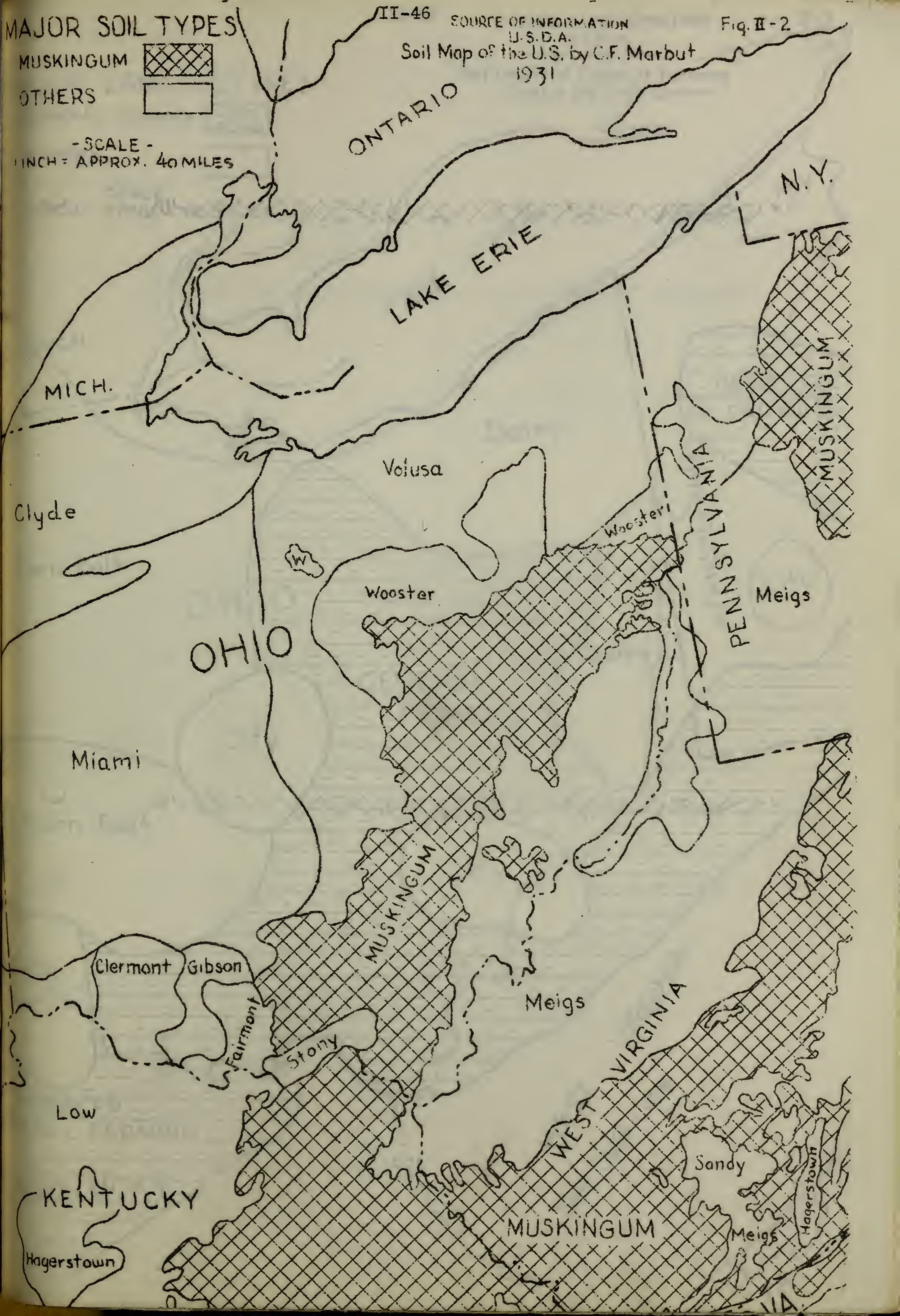
PROPOSED TENTATIVE LOCATION OF EXPERIMENTAL WATERSHEDS

ALTERNATIVE LOCATIONS

Figure II - A

Fig. II-1


MAJOR EROSION TYPES
JOR:
oderate Sheet Erosion
Occasional Gullies (27)
evere Sheet Erosion
occasional Gullies (37)
CONDARY:
ittle or No Erosion (1)
oderate Sheet Erosion (2)
evere Sheet Erosion
Frequent Gullies (38)
oderate Sheet Erosion
Frequent Gullies (28)
Scale:
Inch = Approx. 40 Miles.
Source of Information
S.C.S.
Reconnaissance Erosion
Survey of the U. S.,
1935.
LAKE ERIE
MICH.
OHIO
N.Y.
PENN
WEST VIRGINIA
KENTUCKY


MAJOR SOIL TYPES
MUSKINGUM
OTHERS
-SCALE-
1 INCH = APPROX. 40 MILES
SOURCE OF INFORMATION
U.S.D.A.
Soil Map of the U.S. by C.F. Marbut
1931
Fig. II-2
ONTARIO
LAKE ERIE
N.Y.
MICH.
MUSKINGUM
Volusa
Clyde
Wooster
W
Wooster
PENNSYLVANIA
Meigs
OHIO
Miami
MUSKINGUM
Clermont
Gibson
Fairmont
Meigs
Stony
Low
WEST VIRGINIA
KENTUCKY
Sandy
Hagerstown
MUSKINGUM
Meigs
Hagerstown
VA.

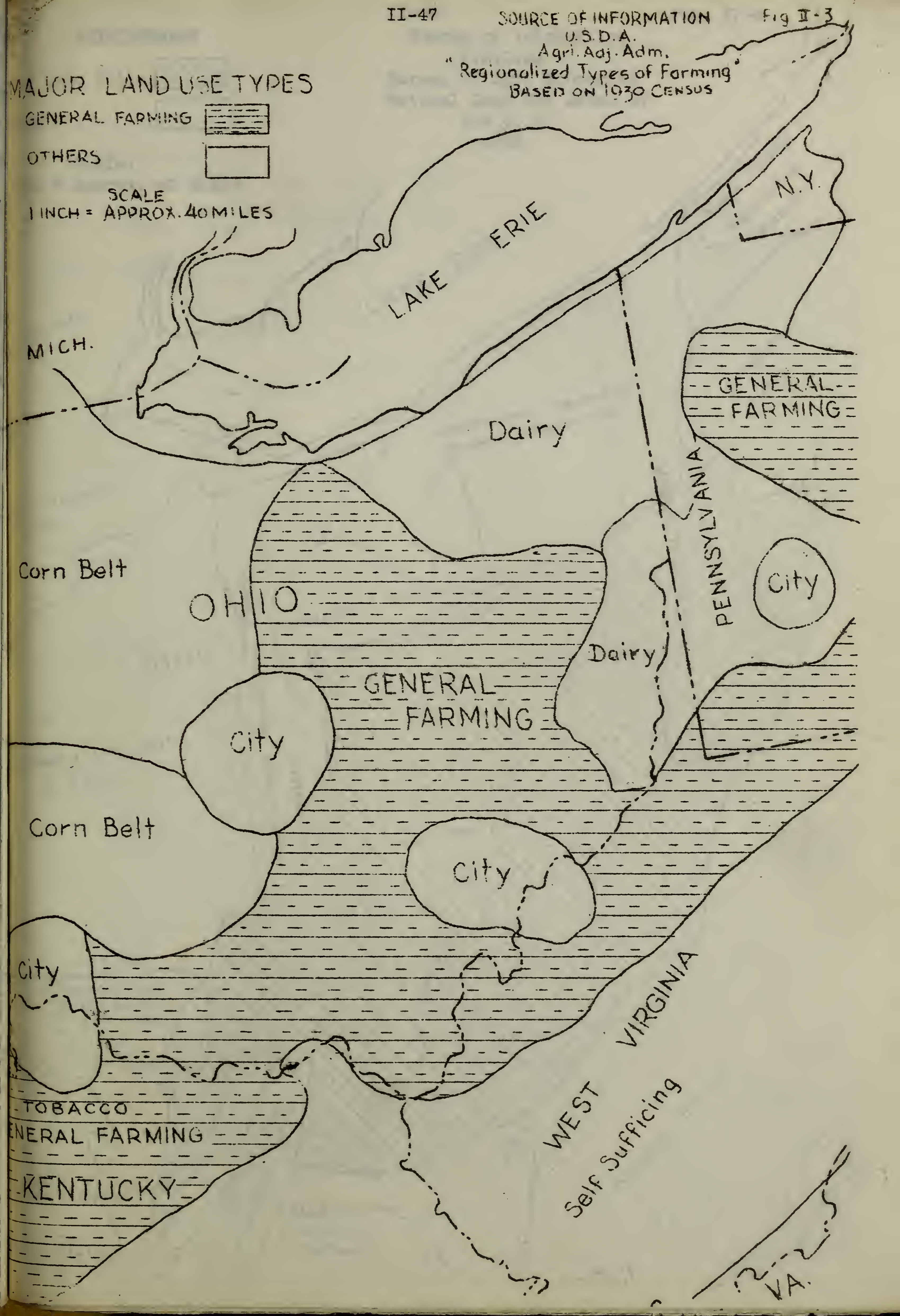

SOURCE OF INFORMATION
U.S.D.A.
Agri. Adj. Adm.
"Regionalized Types of Farming"
BASED ON 1930 CENSUS
Fig II-3
MAJOR LAND USE TYPES
GENERAL FARMING
OTHERS
SCALE
1 INCH = APPROX. 40 MILES
LAKE ERIE
N.Y.
MICH.
Dairy
GENERAL FARMING
PENNSYLVANIA
City
Corn Belt
OHIO
Dairy
GENERAL FARMING
City
Corn Belt
City
City
WEST VIRGINIA
Self Sufficing
TOBACCO
GENERAL FARMING
KENTUCKY
VA.

Fig. II-4

PHYSIOGRAPHY

Source of Information
U.S.D.A.
Bureau of Agr. Economics
Natural Land Use Areas of
the U. S.
1933

Upper Ohio Hills
Others

Scale:
1 Inch = Approx. 40 Miles

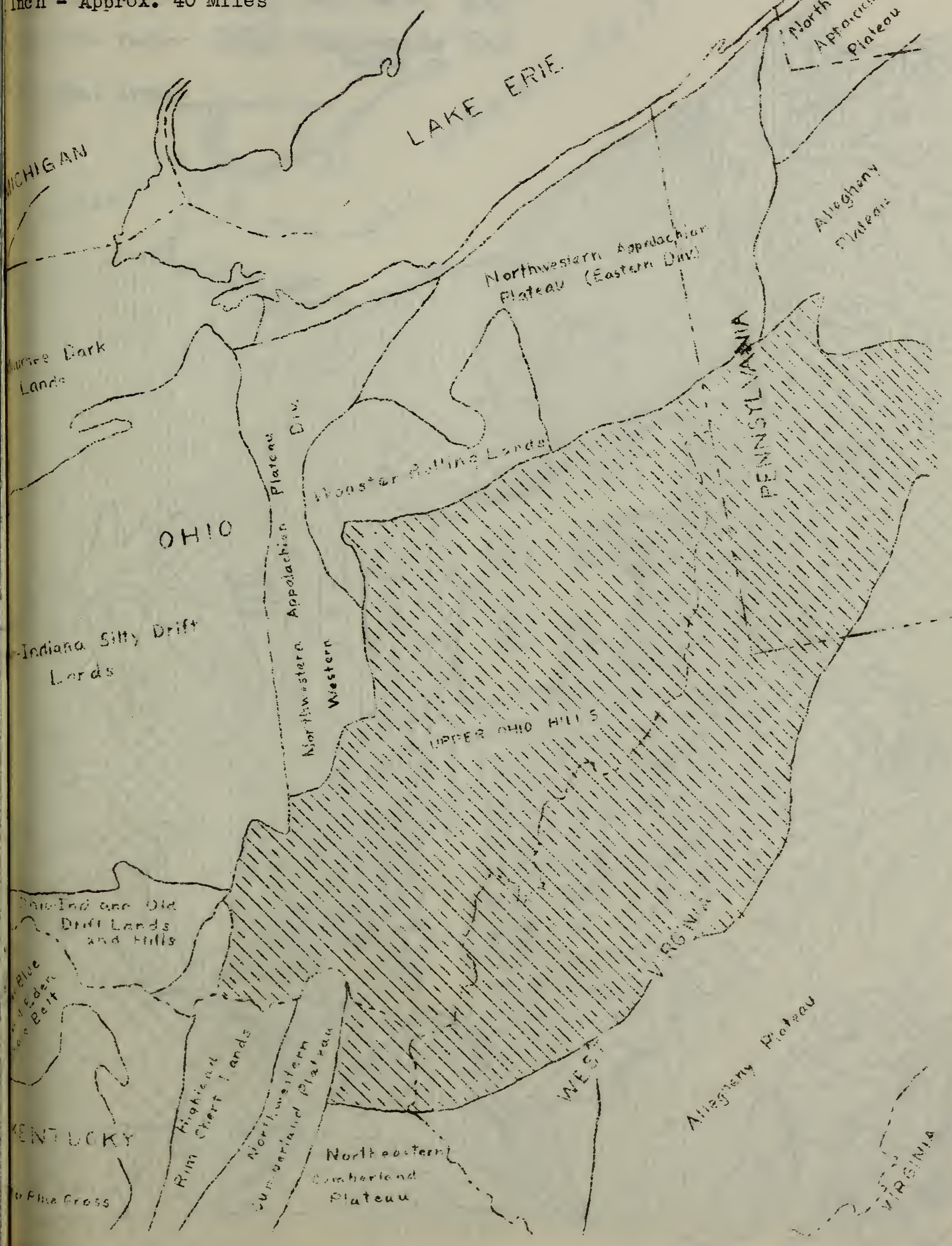


Fig. II-5

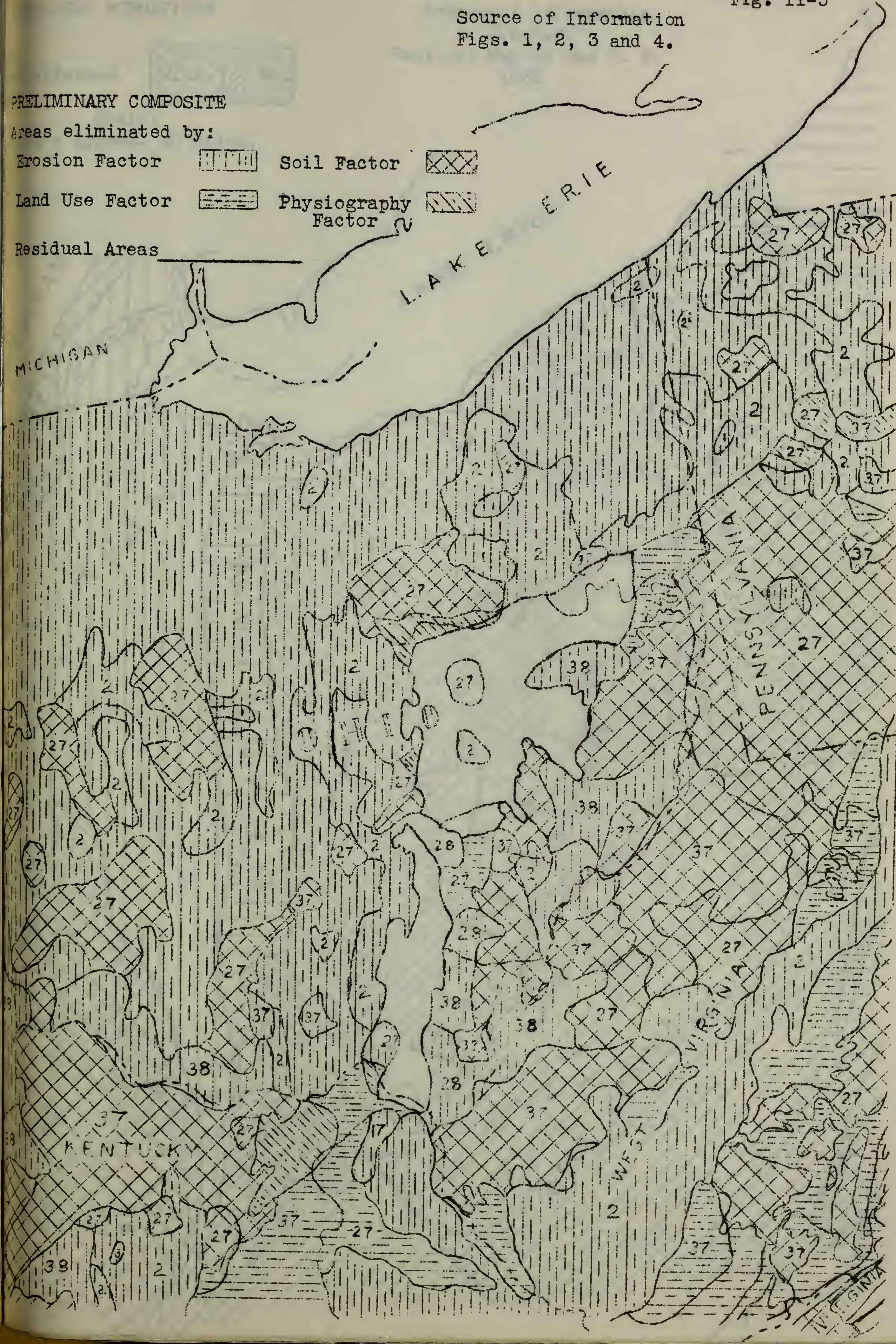
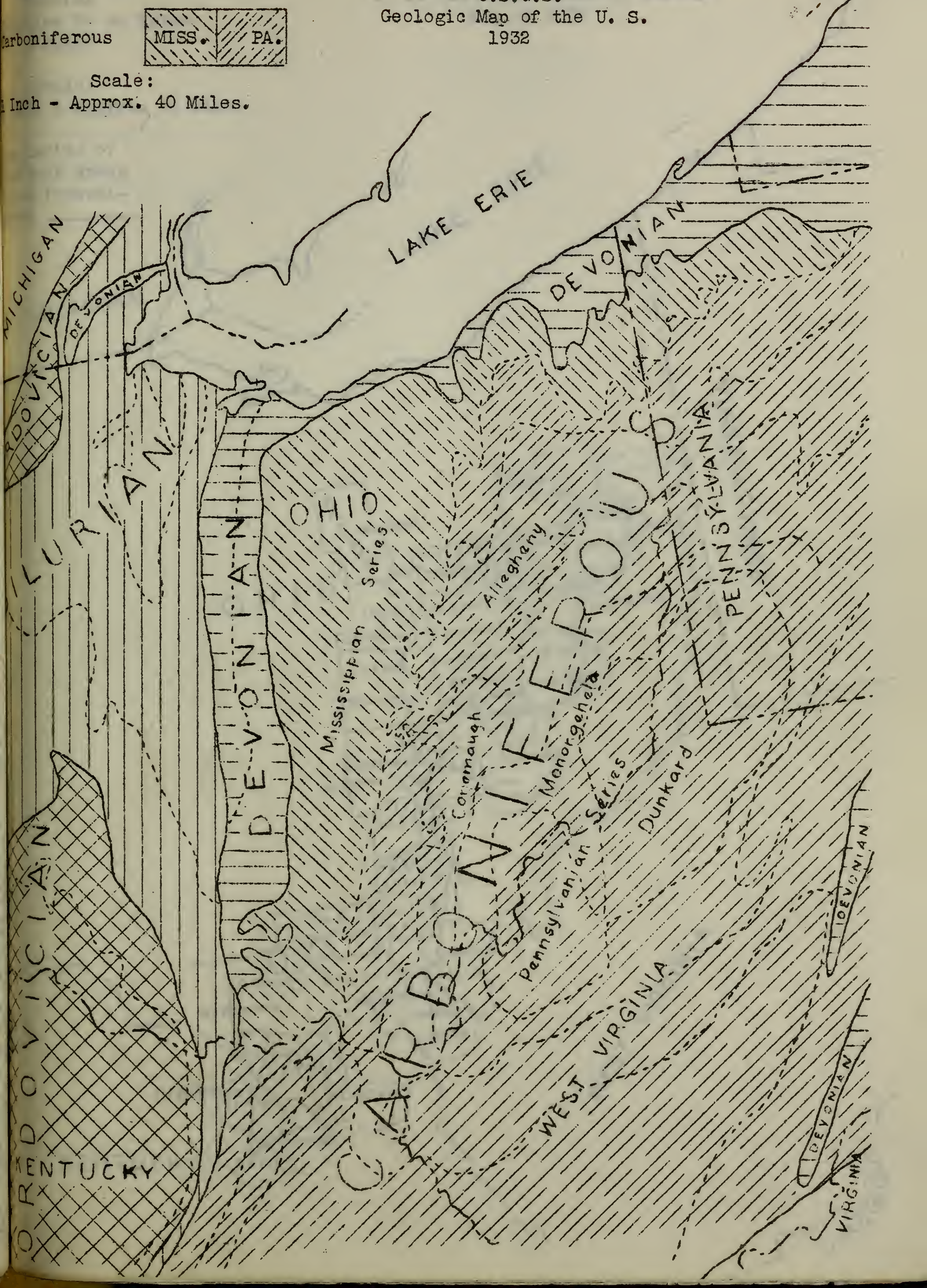

Source of Information
Figs. 1, 2, 3 and 4.
PRELIMINARY COMPOSITE
Areas eliminated by:
Erosion Factor
Soil Factor
Land Use Factor
Physiography Factor
Residual Areas
LAKE ERIE
MICHIGAN
PENNSYLVANIA
WEST VIRGINIA
KENTUCKY
VIRGINIA

Fig. II-6

GEOLOGIC FORMATIONS

Source of Information
U.S.G.S.
Geologic Map of the U. S.
1932



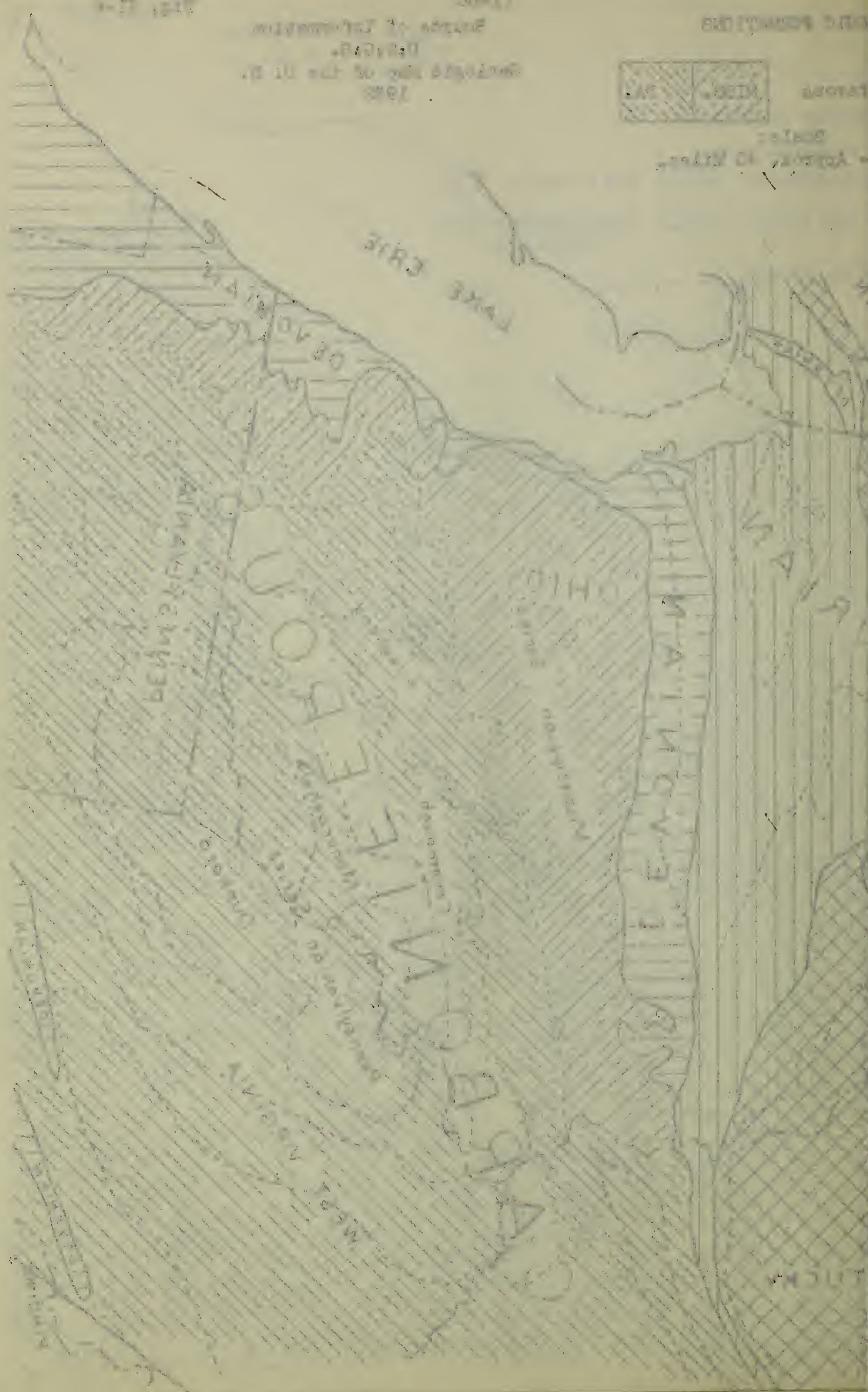


Fig. II-7

Source of Information
U. S. Coast and Geodetic Survey
Map of 1932

AUXILIARY MAP
Showing
Counties to be Inves-
tigated

Scale:
1 Inch = Approx. 40 Miles

Boundaries of
Residual Areas
to be Investi-
gated ———

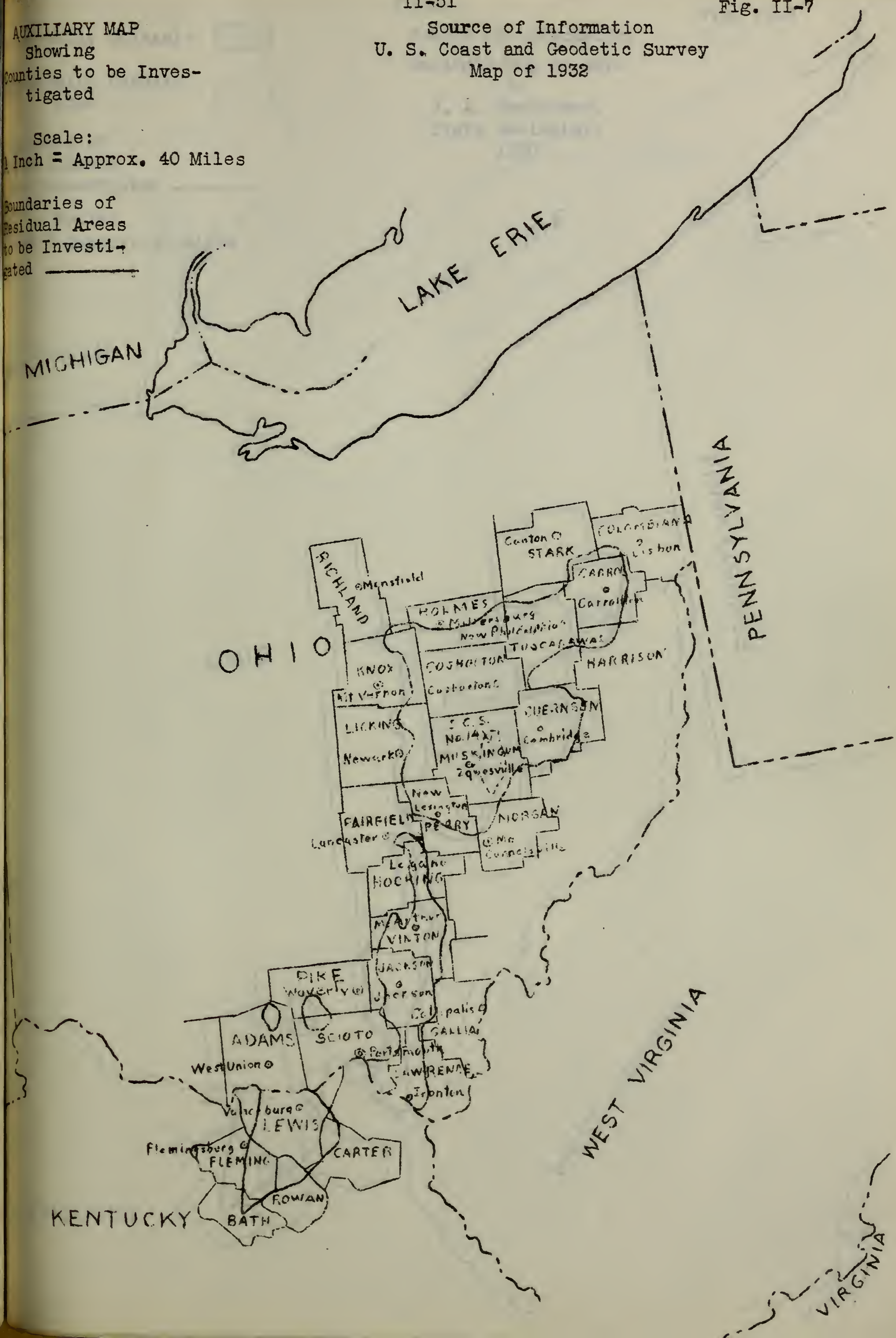
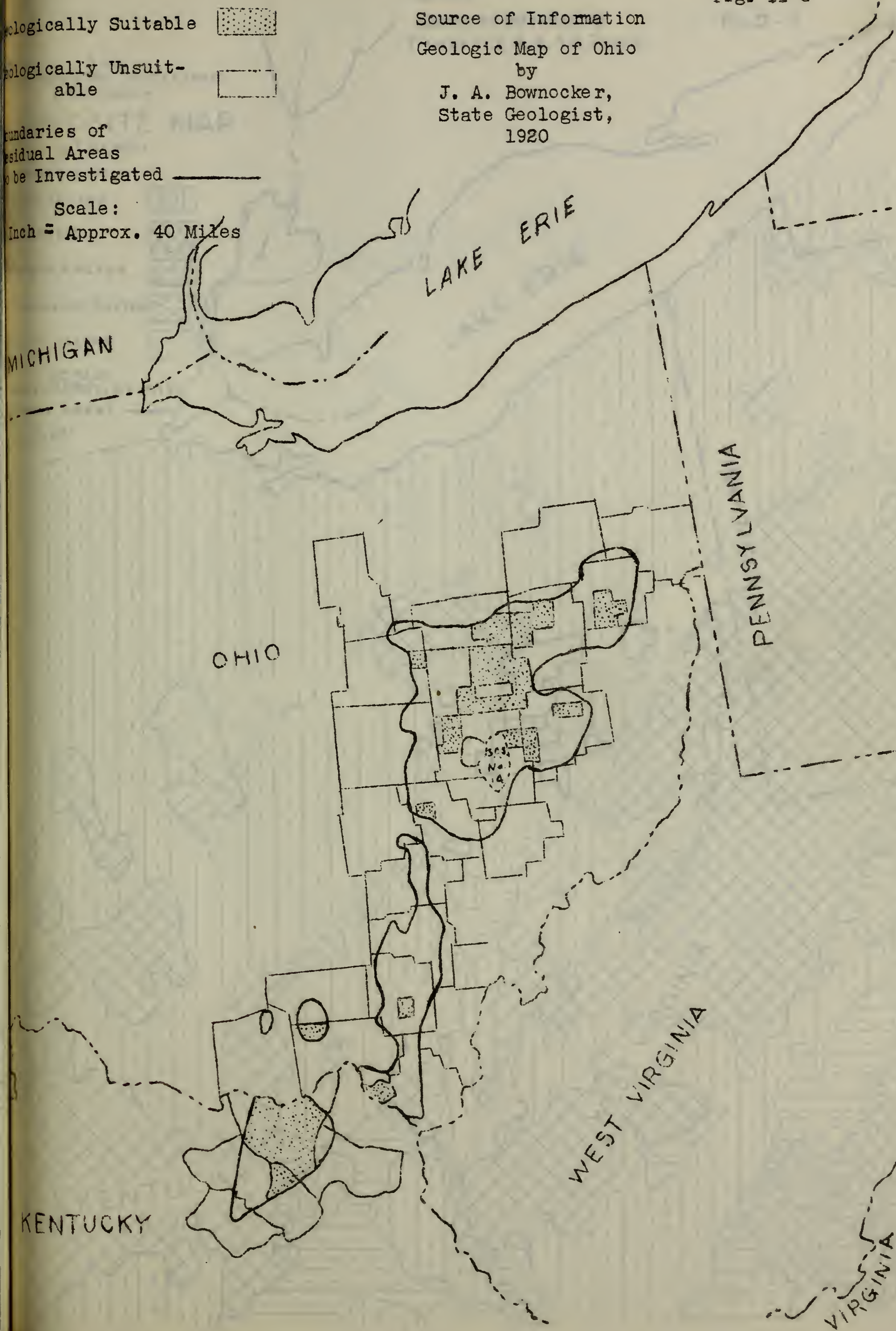


Fig. II-8



Suitable
Unsuitable-
able
of
Areas
Investigated
Scale:
= Approx. 40 Miles
Source of Infomation
Geologic Map of Ohio
by
J. A. Bownocker,
State Geologist,
1920
LAKE ERIE
MICHIGAN
OHIO
PENNSYLVANIA
WEST VIRGINIA
VIRGINIA
KENTUCKY

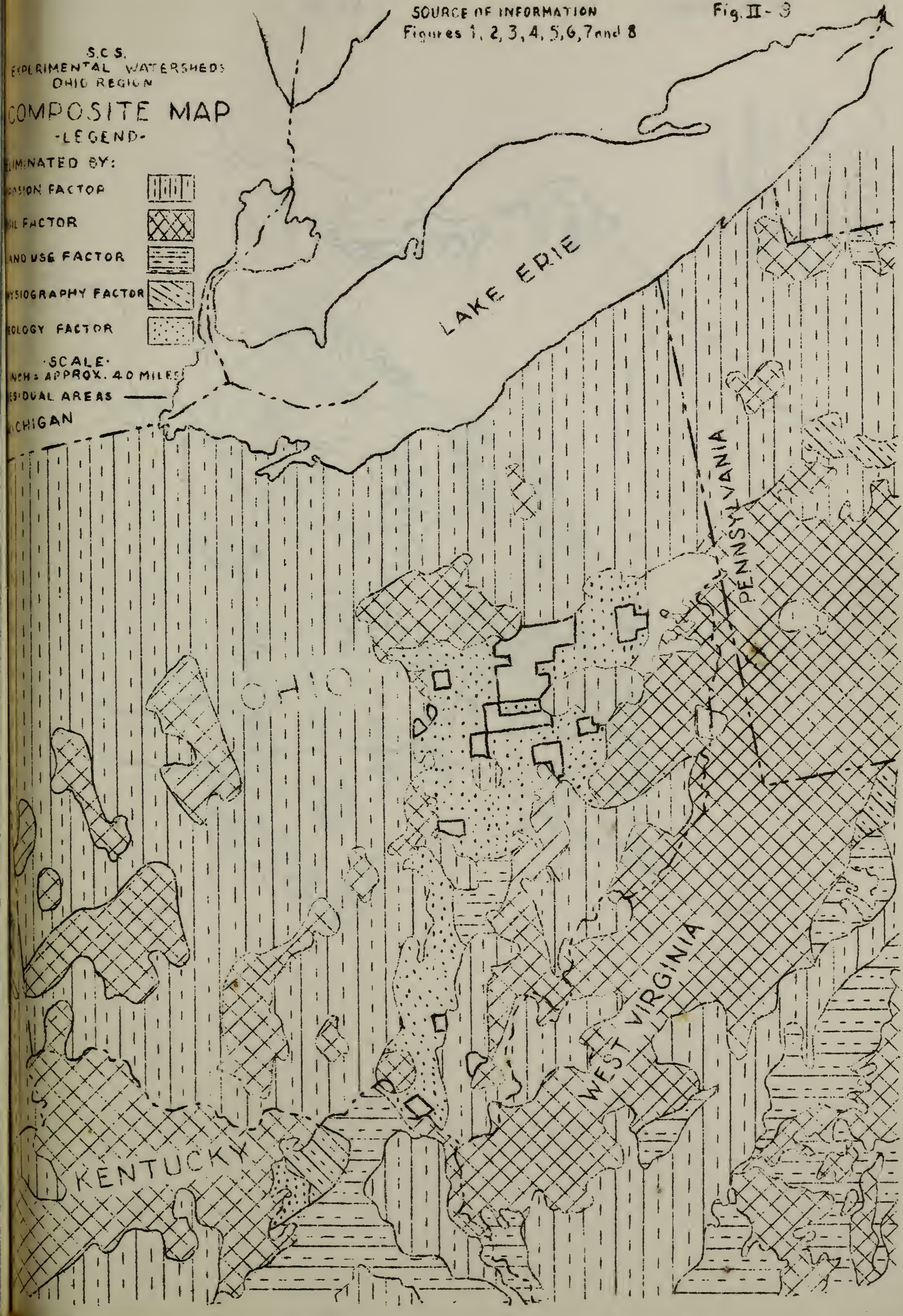

SOURCE OF INFORMATION
Figures 1, 2, 3, 4, 5, 6, 7 and 8
Fig. II- 3
S.C.S.
EXPERIMENTAL WATERSHEDS
OHIO REGION
COMPOSITE MAP
-LEGEND-
LIMINATED BY:
ROSION FACTOR
OIL FACTOR
AND USE FACTOR
HYSIOGRAPHY FACTOR
EOLOGY FACTOR
·SCALE·
NCH = APPROX. 40 MILES
ESIDUAL AREAS
MICHIGAN
LAKE ERIE
OHIO
PENNSYLVANIA
WEST VIRGINIA
KENTUCKY

Figure II-10

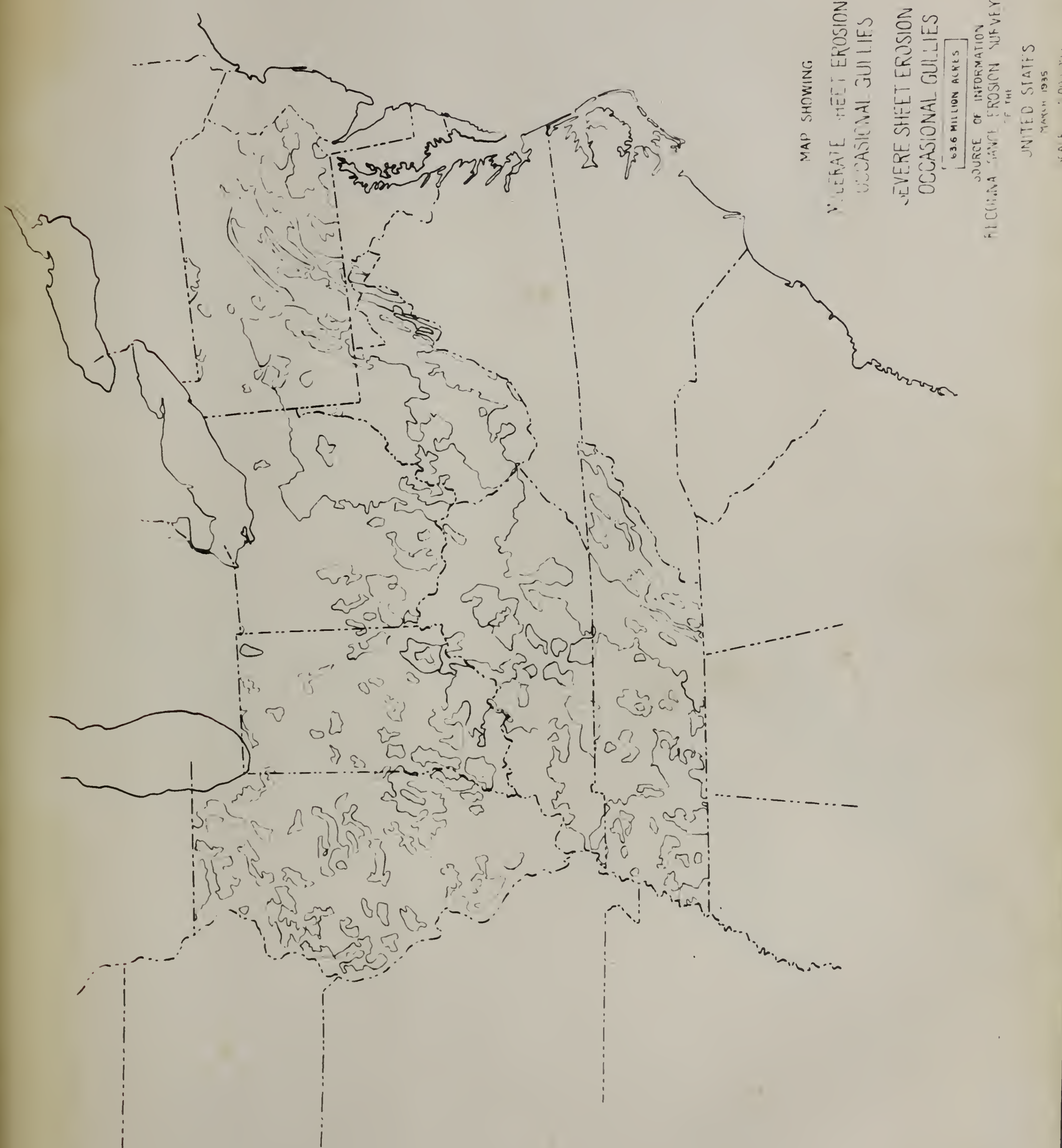

MAP SHOWING
SEVERE SHEET EROSION
OCCASIONAL GULLIES
63.6 MILLION ACRES
SOURCE OF INFORMATION
UNITED STATES
MARCH 1935

Figure II-11

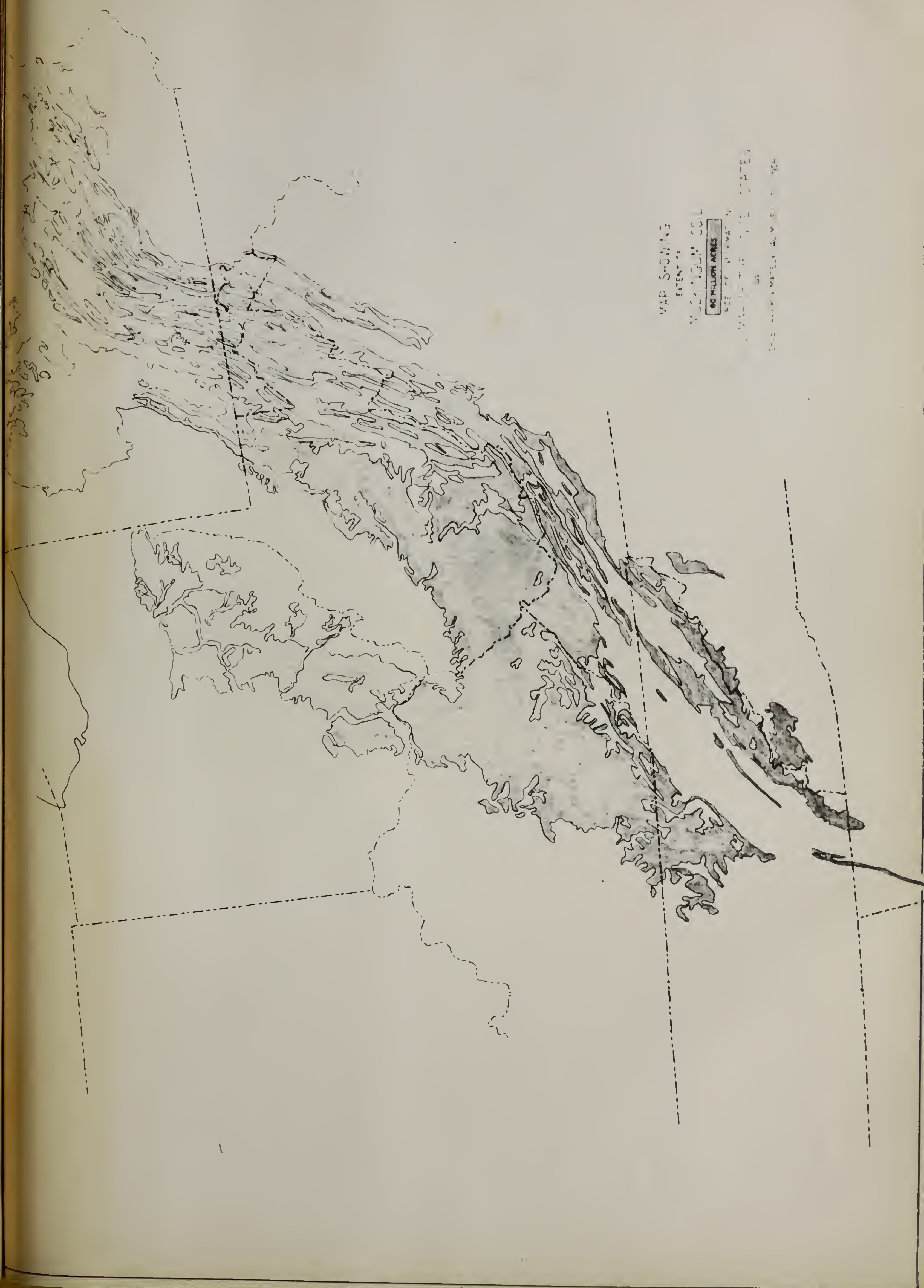
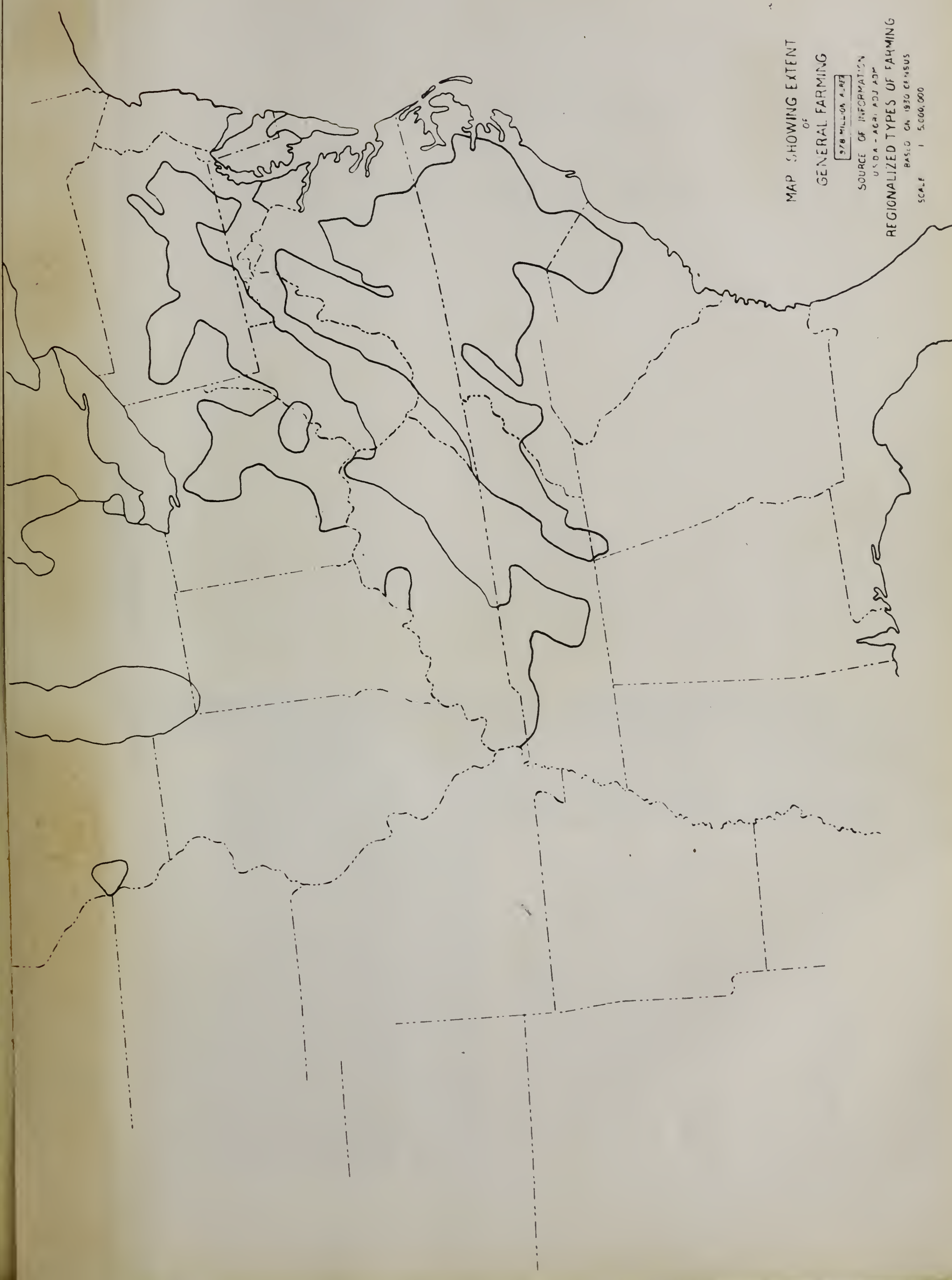


Figure II-12


MAP SHOWING EXTENT
OF
GENERAL FARMING
978 MILLION ACRES
SOURCE OF INFORMATION
U.S.D.A. - AGRI. ADJ. ADM.
REGIONALIZED TYPES OF FARMING
BASED ON 1930 CENSUS
SCALE 1 : 5,000,000

SELECTION OF TYPICAL WATERSHED IN THE OHIO REGION
LEGEND
Oil Producing Territory
Gas Producing Territory
Railroad Shipping (Mostly Coal)
Stripping Coal Mine
Ceramic Plant
Res. Adm. Purchase Area
Normal Pool of M.C.D. Reservoir
BEACH CITY DAM
DOVER DAM


STATE OF OHIO
OHIO
COSHOCTON QUADRANGLE
Green Valley School
Grand Lewisville
TUSCARAWAS
RIVER
Contour interval 20 feet
Datum is mean sea level
Edition of June 1915, reprinted 1925
COSHOCTON, O.

PAGE II - 59

FIGURE II - 15

(Notes to accompany Figure II-15)

RECONNAISSANCE SURVEY OF PROPOSED EXPERIMENTAL WATERSHED Q
COSHOCTON QUADRANGLE -- U. S. G. S.
BASE MAP
AUGUST 25, 1935

By

D. B. Krimgold

Notes recorded by R. B. Hickok

Weather: Fair, slightly cool

1. Good gaging site.

2. Small watershed possibility, pasture and timber.

3. Small timbered watershed possibility.

4. Typical corn and pasture.

5. Excellent possibility for small watershed gaging site.
Fair stream flow August 25, 1935.

6. Possible gaging site, good flow ($1\frac{1}{2}$ to 2 c.f.s.).

7. Intermediate watershed with small watershed possibilities. Feasible gaging.

8. Two (2) small watershed possibilities.
Pasture approximately 25% slope.

9. Possible gaging combined flow from 8.

10. Possibility of small watersheds, pasture, timber, and cultivated typical of section.
Good gaging possibilities.
Grade satisfactory.

11. Possible duplicate watershed.

12 & 12'. Small watershed possibilities.

13. Small timbered watershed possibility.
Slopes 30% to 40%.

14. Duplicate possibility.

15. Typical topography, farm land and timber.

16. Intermediate watershed, flat grade, partly timbered.

17. Good gaging site for 16.

18. Intermediate watershed.
    Gaging for low flow.
    Dam required for higher stages.
    Gaging feasible.

19. Intermediate watershed, pasture and timber.
    Feasible gaging site.
    Rocky.

20. Considerable amount of debris deposited by last flood.

21. Good flow.

22. Good flow in Little Mill Creek.

23. Intermediate watershed, timbered and pastured.

24. Feasible gaging site.

25. Small watershed, cleared steep slopes, pasture.

26. Headwaters of intermediate watershed; abandoned farm. Reason: age of owner. Was a good farm before owner became too old to operate it.

27. Typical meadow, corn, and timber.

28. Intermediate watershed, flat grade, slopes rather steep. Cultivated pasture and timber.

29. Large commercial mine. Shaft entrance at ridge.
    Abandoned.

30. Intermediate watershed, timbered.

31. Gaging possible with small dam.

32. Possible small watershed, pasture.

33. Small timbered watershed.

34. Small cultivated watershed. 10% to 12% slope on west side.
    Watercourse 15% to 20%.

35. Wheat stubble.

36. Badly eroded slope.

37. Good intermediate watershed with severe sheet erosion and shallow gullies.

38. Intermediate watershed, timbered at headwaters.

39. Heavy debris deposits from recent flood.

40. Gaging possibility.

41. Abandoned mine (commercial)?

42. Possible duplicate of 37.

43. Possible intermediate duplicate. Cultivated; in timber at headwaters.

44. Heavily timbered headwaters. Good forest litter.

45. Cultivated.

46. Feasible gaging.

47. Bridge out.

48. Typical cultivated, slopes about 20%.

General Remarks: Area quite typical.

Pro: A large number of feasible gaging sites available.

Good possibility of conjugate small and intermediate watersheds.

Good possibility of intermediate check watersheds immediately adjoining the master watershed.

Good system of major all-weather roads. Yet enough road improvement can and should be done which will employ a considerable number of relief labor.

Con: Does not drain into any present or proposed Muskingum Conservancy District reservoirs. Land as a whole not submarginal. Therefore purchase by Resettlement Administration may not be possible.


MECHANIC
CLARK
Holmes Co.
Coshocton Co.
MILL CREEK
CRAWFORD
Q
Q"L"
KEENE
COMPOSITE PROPERTY MAP
II — 16
LEGEND
A,A',B&C SMALL WATERSHEDS, 5 TO 15 ACRES EACH
20 YEAR LEASE OR OUTRIGHT PURCHASE
PARSHALL SLUME - 1/2 TO 2 ACRES
20 YEAR LEASE OR EASEMENT
GAGING SITE- 1 TO 3 ACRES
20 YEAR LEASE OR EASEMENT
ALTERNATIVE AREAS FOR SMALL WATERSHEDS
30 TO 40 ACRES TO BE PURCHASED BY THE GOVERNMENT

FIG. II - 17
LEGEND

A'	- SMALL TIMBERED WATERSHED 5 TO 15 ACRES EACH
A,B,C	- SMALL WATERSHEDS, 5 TO 15 ACRES EACH ON SLOPES OF 20%, AND UP, 12% TO 20%, AND UP TO 12%, RESPECTIVELY (APPROXIMATE LOCATIONS)
⚒	- SMALL WAGON MINES
)(	- PARSHALL FLUME GAGING STATION
✻	- BRIDGE OR CABLE GAGING STATION
----	- ALTERNATIVE AREAS FOR SMALL WATERSHEDS
▬	- SITES FOR HEADQUARTERS, LYSIMETERS & PLOTS (TENTATIVE)

TOTAL AREA: W - 7.28 SQ. MILES OR 4659 ACRES
TOTAL AREA: W" - 6.39 SQ. MILES OR 4090 ACRES

DRAINAGE AREAS CONTRIBUTING TO GAGING STATIONS

STATION NO.	DRAINAGE AREA SQ. MILES	ACRES
8'	.106	68
2	.108	69
11	.158	101
4	.170	109
8	.200	128
10	.242	155
7	.360	230
1	.428	274
13	.487	312
15	.554	355
3	.622	398
14	.659	422
9	.733	469
12	.745	477
9'	.749	479
1	1.067	683
5	1.280	819
II	2.017	1291
6	2.710	1734
III	6.098	3903
IV	7.152	4577

(Notes explanatory of Figure II-14)

METHOD OF ARRIVING AT SLOPE, SOIL, AND LAND USE DISTRIBUTION

A reconnaissance survey of the Muskingum Watershed has been made by the Soils Department of the Soil Conservation Service, Project #14, Zanesville, Ohio. The results were plotted on U. S. G. S. Quadrangle sheets (see Map #II-14). The legend used is as follows:

$$\frac{\text{Soils - Land Use}}{\text{Slope - Erosion}} \text{ or } \frac{\text{1 - PL}}{\text{BB-C-37}}$$

where: 1 = Muskingum silt loam

PL = App. 60% Pasture 40% Cultivated

BB-C = Predominately BB slope with some C

37 = 3, - 25% to 75% top soil eroded

7, - Occasional shallow gullies. Gullies are less than 2 feet deep and over 100 feet apart.

	SOILS	LAND USE	SLOPES
1	Muskingum silt loam		
2	Muskingum loam	P = Pasture	
3	Wellston silt loam	L = Cultivated	
4	Zanesville silt loam	F = Woods	A = 0 to 5%
5	Westmoreland silt loam	X = Idle Land	B = 5% to 12%
6	Belmont silty clay loam		BB = 12% to 20%
7	Meigs silty clay loam		C = 20% to 30%
8	Upshur clay		D = 30% +
9	Huntington series		
10	Linside series		
11	Philo series		
12	Moshannon series		
13	Monongahela silt loam		
14	Chenango series		
15	Wheeling series		

EROSION

1. No apparent erosion. This occurs on level areas or heavily wooded areas that have a good cover of leaf litter.

2. Slight. Less than 25% of the surface soil is removed.

3. Moderate. 25% to 75% of surface soil removed.

4. Severe. Over 75% of surface soil lost.

5. Very severe. Only 4 to 6 inches of soil material remaining over parent rock.

6. Shallow slips. Landslides that have dropped less than 3 feet.

6V. Deep slips. Slips that have dropped more than 3 feet.

7. Occasional shallow gullies. Gullies are less than 2 feet deep and over 100 feet apart.

7V. Occasional deep gully. Gullies are over 2 feet deep and over 100 feet apart.

8. Severe shallow gullies. Gullies are less than 2 feet deep and between 30 and 100 feet apart.

8V. Severe deep gullies. Gullies are over 2 feet deep and between 30 and 100 feet apart.

9. Completely destroyed by gullies less than 2 feet deep.

9V. Completely destroyed by gullies of more than 2 feet in depth.

Information given in Table No. 1, Columns 22, 23, and 24 was arrived at as follows:

Where an area was mapped as a combination of two or three classifications of Land Use, the following percentages were given to each:

SYMBOL	F - FOREST % of Total	P - Pasture % of Total	L - Cultivation % of Total
F	80	10	10
FP	60	40	
FL	55		45
FPL	40	35	25
FLP	40	25	35
P	10	80	10
PF	35	55	10
PL		60	40
PFL	35	40	25
PLF	25	40	35
L	5	5	90
LP		40	60
LF	30		70
LPF	25	35	40
LFP	35	25	40

SOILS DISTRIBUTION

Muskingum silt loam, Muskingum loam, and Wellston silt loam were listed as typical Muskingum soils. The remaining soil types were listed under others unless some one soil type was 60% or more of the others; then it was listed separately in percent of the total.

SLOPE DISTRIBUTION

Where two slopes were listed, the predominating slope was tabulated and the minor slope discarded.

A P P E N D I X III

COOPERATIVE AGREEMENT
TO BE SIGNED WITH FARMERS ON
THE EXPERIMENTAL WATERSHED

UNITED STATES
DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

- - - - -

COOPERATIVE AGREEMENT

Agreement for experimental work to determine the effect of rational land use and erosion control measures on run-off, floods, and water conservation by measuring soil and water losses and factors affecting these losses on watersheds ranging in size from 5 to 5,000 acres.

The site of the work, with land description, cropping plan, and map attached hereto, are incorporated as part of the agreement.

THIS AGREEMENT, entered into this __________ day of __________, 19__,

by the United States of America, hereinafter called the Government, repre-

sented by the contracting officer executing this contract and

(Last name)	(First name)	(City)	(State)
(Last name)	(First name)	(City)	(State)
(Last name)	(First name)	(City)	(State)
(Last name)	(First name)	(City)	(State)
(Last name)	(First name	(City)	(State)

hereinafter called the Cooperator(s);

Witnesseth, that the parties hereto do mutually agree as follows:

Article 1. The officer in charge shall be the Superintendent, hereinafter called the officer in charge.

Article 2. The Cooperator agrees to follow the cropping plan attached hereto, in accordance with the directions and under the guidance of the officer in charge or his duly authorized representatives, insofar as the officer in charge may find it necessary for the purposes of soil erosion control and rational land use. The obligations of the Cooperator, however, shall be limited to those set forth in

article 3 ____

Article 3. For a period of 20 years from the date of this agreement, the Cooperator agrees to continue all farming, forestry, grazing, and fire control practices required by this agreement and to maintain all fences, terraces, and other structures erected pursuant thereto, in a condition and in a manner satisfactory to the officer in charge.

Article 4. The Cooperator agrees to plant grass, hay, or other erosion-resisting vegetation, at locations indicated on the attached map:

____

____

____

The Cooperator further agrees to maintain in pasture grass or hay ________ acres, as indicated on the map. The plowing of permanent grass or hay land, the clearing of brush or woodland, and the grazing of pasture land shall be subject to the approval of the officer in charge.

Article 5. The Government agrees to furnish seed, lime, fertilizer, and inoculating materials for areas taken out of cultivation as may be specified in the cropping plan and enumerated below:

____

____

____

____

Article 6. The Government agrees to make surveys, prepare specifications, and do the necessary work for ____________ acres of strip-cropping at locations indicated on the map. The Cooperator agrees to practice contour strip-cropping on said locations, as specified by the Government. No one cultivated crop shall occupy the same location in a field for more than ________ years in succession.

Article 7. The Government agrees to plant trees, shrubs, or other erosion-resisting vegetation on__________acres, at locations indicated on the map.

Article 8. It is stipulated, since this stock is furnished free, that trees may not at any time be sold or disposed of, except as commercial wood products and with the consent of the officer in charge.

Article 9. The Cooperator agrees to furnish all materials and labor which are available to him and may be required in such construction or relocation of fences as may be necessitated by the cropping plan attached hereto. When, in the opinion of the officer in charge, the Cooperator is unable to furnish such necessary materials or to furnish such labor, the Government agrees to assist the Cooperator in such construction and relocation of fences by furnishing such material and labor as the officer in charge deems necessary.

Article 10. The Cooperator agrees to protect from grazing __________acres, at locations indicated on the map.

Article 11. The Cooperator agrees to assist the officer in charge in the prevention and suppression of fires on all wooded and other areas not used for farm crops.

Article 12. The Government agrees to make surveys and specifications for contour-furrowing of pasture land on_________acres, as indicated on map. The Cooperator agrees to perform said contour-furrowing according to the Government surveys and specifications.

Article 13. The Government agrees to make surveys, prepare specifications, and build terraces on_________acres, as mutually agreed upon. The Cooperator agrees to assist in constructing said terraces according to the Government surveys and specifications.

Article 14. The Government agrees to furnish temporarily the following terracing tools and equipment as available:

____

____

Article 15. The Cooperator agrees to do whatever_______________ _____work is necessary for moving the local materials to build the following erosion-control structures, as agreed upon:

____

____

____

Article 16. The Government agrees to build the necessary structures and devices which may be deemed necessary and practical in special cases to prevent damage from uncontrolled waters entering upon farm from neighboring lands.

Article 17. In order that the Government may direct and supervise the work, the farming, and the forestry practices undertaken in this agreement, the Cooperator shall allow the officer in charge and his duly authorized agents free access to any of the lands involved during the period of this agreement.

Article 18. In the event that the Cooperator fails to fulfill his undertaking in a satisfactory manner the parties agree that the Government may terminate this agreement and shall be entitled to recover as liquidated damages the cost of materials (but not equipment) used by the Government, and cash compensation to Cooperator under this agreement.

Article 19. The Cooperator agrees that the Government shall not be liable for any injury to person or property incurred in connection with the prosecution of the work under this agreement.

Article 20. If at any time a party hereto shall cease to have any legal relationship (whether as landlord or tenant) to the land described on the map attached hereto and incorporated as part of the agreement, this contract shall become inoperative and of no further force or effect as to such party.

Article 21. In event present or future farm legislation interferes with the cropping plan of this agreement the needed changes may be made subject to the approval of the officer in charge.

Article 22. No Member of or Delegate to Congress or Resident Commissioner shall be admitted to any share or part of this contract or to any benefit that may arise herefrom, but this restriction shall not be construed to extend to this contract if made with a corporation or company for its general benefit.

Article 23. It is understood and agreed that the United States is not bound by the terms of this agreement for any amount in excess of available appropriations nor beyond the period or periods authorized by existing law or as may be hereafter provided.

The parties hereunto have executed the same, the United States of America by the contracting officer, and the Cooperator has hereunto signed his name and affixed his seal the day and year hereinabove written.

THE UNITED STATES OF AMERICA,

____
Superintendent

(Seal) ____________________ ____________________
Cooperator (Title-owner or operator)

(Seal) ____________________ ____________________
Cooperator (Title-owner or operator)

(Seal) ____________________ ____________________
Cooperator (Title-owner or operator)

(Seal) ____________________ ____________________
Cooperator (Title-owner or operator)

(Seal) ____________________ ____________________
Cooperator (Title-owner or operator)

Witnesses:

____

____

____

____
Contracting Officer

A P P E N D I X   I V

CURVES GIVING RATES OF RUN-OFF

Extracts from "Brief Instructions on Methods of Gully Control"

(Pages 15 to 27)

by

C. E. Ramser,

Senior Drainage Engineer

UNITED STATES DEPARTMENT OF AGRICULTURE

August 1933

A P P E N D I X IV

CURVES GIVING RATES OF RUN-OFF
DEVELOPED BY
MR. C. E. RAMSER

(Taken from "Brief Instructions on
Methods of Gully Control" by C. E. Ramser)

HYDRAULICS OF EROSION CONTROL

The control of gullies is fundamentally a drainage problem. The proper design of the control structures requires an intimate knowledge of the science of hydraulics relating principally to the laws of run-off and the flow of water in open channels, weirs, spillways, and culverts. Run-off is the basis of the hydraulic design and must be determined for any particular watershed before it is possible to proceed with the design of the control structures. Hence, it is obvious that the success of a gully control project depends primarily upon the accurate determination of the run-off. Unless it is planned to store all of the run-off water from a watershed, the rate or intensity of the run-off is much more important than the amount, since the discharge capacity of spillways and culverts must be sufficient to take care of the high rates of run-off.

The rate of run-off from a drainage area or watershed depends principally upon the size and shape of the watershed, the slope of the land, the intensity and duration of the rainfall, the vegetative covering, the permeability of the soil, and the slope and condition of the drainage channels. The greatest rate of run-off will, of course, occur for rains of maximum intensity after the watershed is completely saturated. The most accurate and satisfactory method of determining the rate of run-off for any particular watershed is to make a close study of all factors influencing run-off and then compute the probable rate of run-off for a rate of rainfall of a given frequency. Rates of rainfall for periods of 5 minutes to about 1 hour are the ones that produce the highest rates of run-off from comparatively small and sloping watersheds such as are found on most erosion control projects. The frequency with which given rates of rainfall may probably occur play an important part in the design and the engineer must determine whether a structure should be designed to care for such rates of precipitation as occur once a year, once in 100 years, or some intermediate time interval.

The Rational Method of computing run-off is generally regarded as the most accurate in use since it makes provision for all factors affecting run-off. It is based upon the proposition that the maximum rate of run-off from any watershed area for a given intensity of rainfall occurs when all parts of the area are contributing to the flow. That part of the watershed nearest the outlet must still be contributing to the flow when the water from the most remote point on the watershed reaches the outlet. To fulfill this condition, the rain must continue as long as is required for the water to travel from the most remote point of the watershed to the lower end. This interval is called the time of concentration for the watershed. The maximum rate of run-off would therefore result from a rainfall of maximum uniform intensity continuing for a time equal to or exceeding the time of concentration. The following formula is used in computing the rate of run-off by the Rational Method:

$$Q = C\ I\ A$$

Where Q = Rate of run-off in cubic feet per second.

C = Run-off coefficient or coefficient of imperviousness, representing the ratio of the rate of run-off to the rate of rainfall.

I = Rainfall intensity in cubic feet per second per acre, or approximately in inches per hour.

A = The watershed area in acres.

A complete discussion of the Rational Method, giving experimental results and examples showing its practical application, is given in a reprint from the Journal of Agricultural Research, Vol. 34, No. 9, entitled "Run-off from Small Agricultural Areas." A study of this article should enable the engineer to determine the rate of run-off to be used in the design of erosion control structures with a considerable degree of precision for any particular watershed.

In order to facilitate the work of determining the proper rate of run-off to be used for any particular watershed, three sets of curves have been prepared, giving rates of run-off in cubic feet per second for watersheds of different sizes and with different characteristics. The curves given in figure 14 are for watershed areas up to 30 acres and for rainfall intensities with probable frequency of once in 10 years. The other two sets of curves in figures 15 and 16 are for watershed areas ranging from 30 to 1,000 acres and for probable rainfall frequencies of once in 10 years and once in 50 years respectively. Structures that would not be materially damaged by the capacity of the waterway being exceeded, should be designed to take care of such rains as occur once in 10 years and, where damage of a serious nature, or large financial loss would result from the capacity of the waterway being exceeded, should be designed for a probable rainfall frequency of once in 50 years.

Values of C used in making computations by the Rational Method are as follows for the different types of watersheds: - Cultivated rolling, 0.6; cultivated hilly, 0.72; pasture rolling, 0.36; pasture hilly, 0.42; timber rolling, 0.18; timber hilly, 0.21. By "rolling" is meant land with slopes of 5 to 10 percent and by "hilly", slopes of 10 to 30 percent. Other values for C may be used where conditions on watershed warrant and the ratio of the value chosen to the above values, times the rate of run-off given by the curve, will give the rate of run-off for the new value selected for C.

Rainfall intensities used in computing the values for the curves in figures 14, 15, and 16, are for the area marked group No. 3 on the map in figure 17 taken from Meyers Hydrology. In order to determine rates of run-off for the other areas represented by groups shown in this figure, it is necessary to determine the ratio of the rainfall intensities in these groups to those in group No. 3. These ratios are given in Table No. 2 for the various groups for rainfall frequencies of

once in 10 and once in 50 years. For example, to determine the rate of run-off from 100 acres of cultivated rolling land in group No. 2, the rate is first determined for group 3 from figure 15. This is found to be 260 second feet. The ratio of the rainfall intensity for group 2 to that of group 3 for 100 acres is 1.19. Multiplying 260 second feet by 1.19, the result, 309 second feet is obtained, which is the rate of run-off to use for 100 acres in the area marked group No. 2 in figure 17.

WATERSHED

A reconnaissance survey should be made of the watershed to determine whether it should be classified as rolling or hilly, to determine approximate acreage of cultivated, pasture, and timber lands, and to determine the size of the watershed area in acres. The growing tendency is to place more land in pasture or timber so that ordinarily it would be safe to assume that the proportion of pasture and timber area would not be reduced. However, if definite information is available that it is the intention to clear for cultivation, pasture or timber land, then proper consideration should be given this matter in classifying the lands of the watershed.

The area of the watershed can often be closely determined from the location of land lines and pacing any distances required. Where this is not possible, the area can be determined approximately by a compass traverse, using the pacing method to determine distances. This traverse survey should then be plotted with a protractor and area computed or determined with a planimeter. Where a transit is available, a quick stadia traverse survey can be made or, for a small watershed, the bearing and distance to points on the boundaries of the watershed area can quickly be determined from one location of the transit.

TABLE 2

RATIOS OF RAINFALL INTENSITIES IN
GROUP NO. 3 TO THOSE IN GROUPS GIVEN BELOW

Area in acres	Rainfall frequency = once in 10 years				Once in 50 years			
	Group to which ratios apply							
	Group 1	Group 2	Group 4	Group 5	Group 1	Group 2	Group 4	Group 5
1	1.15	1.08	0.90	1.02	1.02	1.06	0.95	0.97
10	1.22	1.12	0.90	0.97	1.07	1.08	0.94	0.94
50	1.29	1.16	0.89	0.89	1.14	1.11	0.92	0.90
100	1.34	1.19	0.89	0.86	1.20	1.13	0.91	0.87
200	1.42	1.23	0.89	0.83	1.30	1.15	0.89	0.83
400	1.50	1.27	0.89	0.80	1.42	1.18	0.89	0.80
600	1.55	1.30	0.88	0.78	1.49	1.21	0.89	0.78
800	1.58	1.32	0.88	0.76	1.56	1.23	0.88	0.77
1000	1.62	1.33	0.88	0.75	1.61	1.24	0.88	0.76

Taken from Table 15, Meyer's Elements of Hydrology, first edition
See Figure 17 for location of areas of groups given in Table

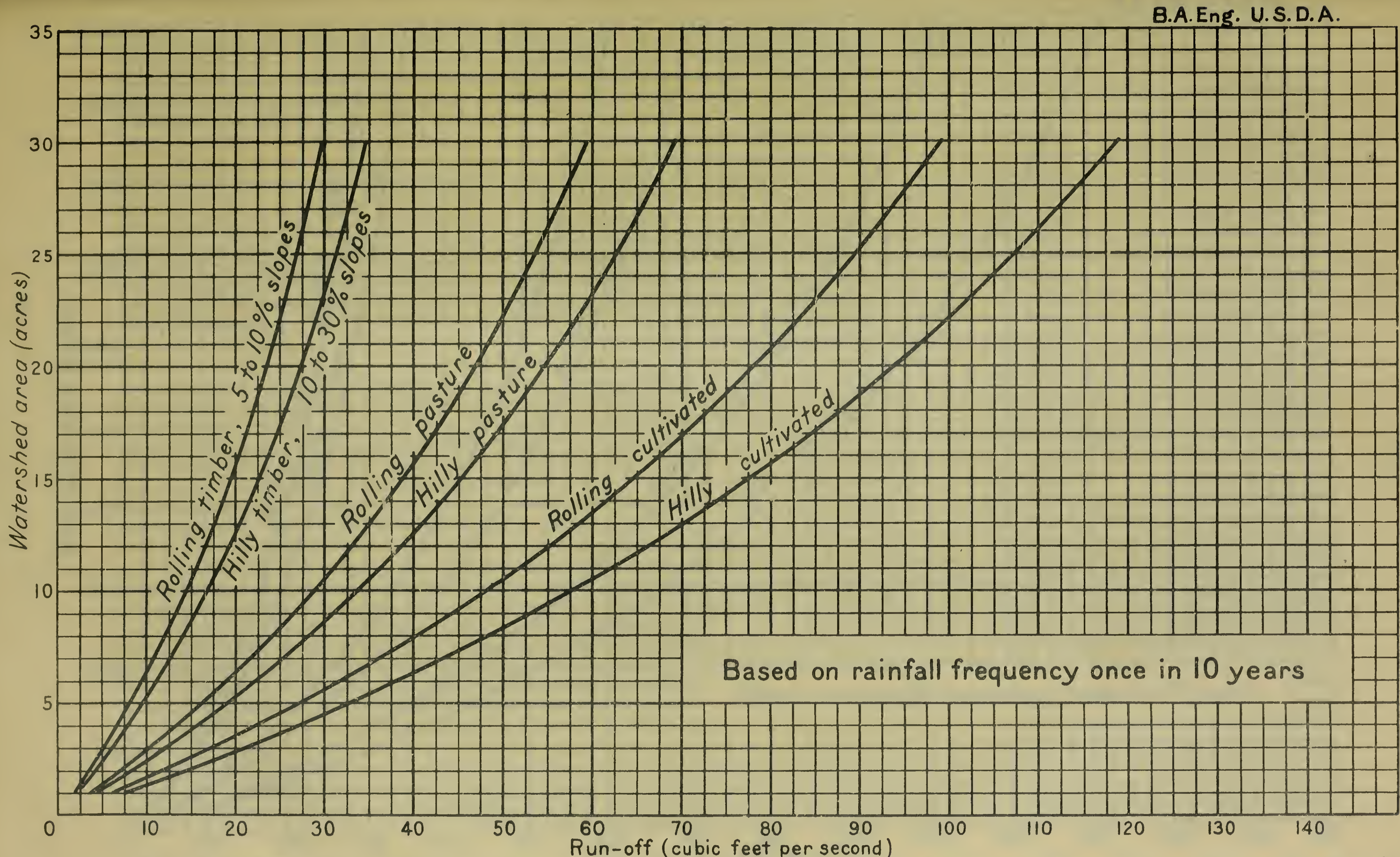


Fig. 14.—Rates of run-off from timber, pasture, and cultivated watersheds for area group no. 3 shown in Fig. 17

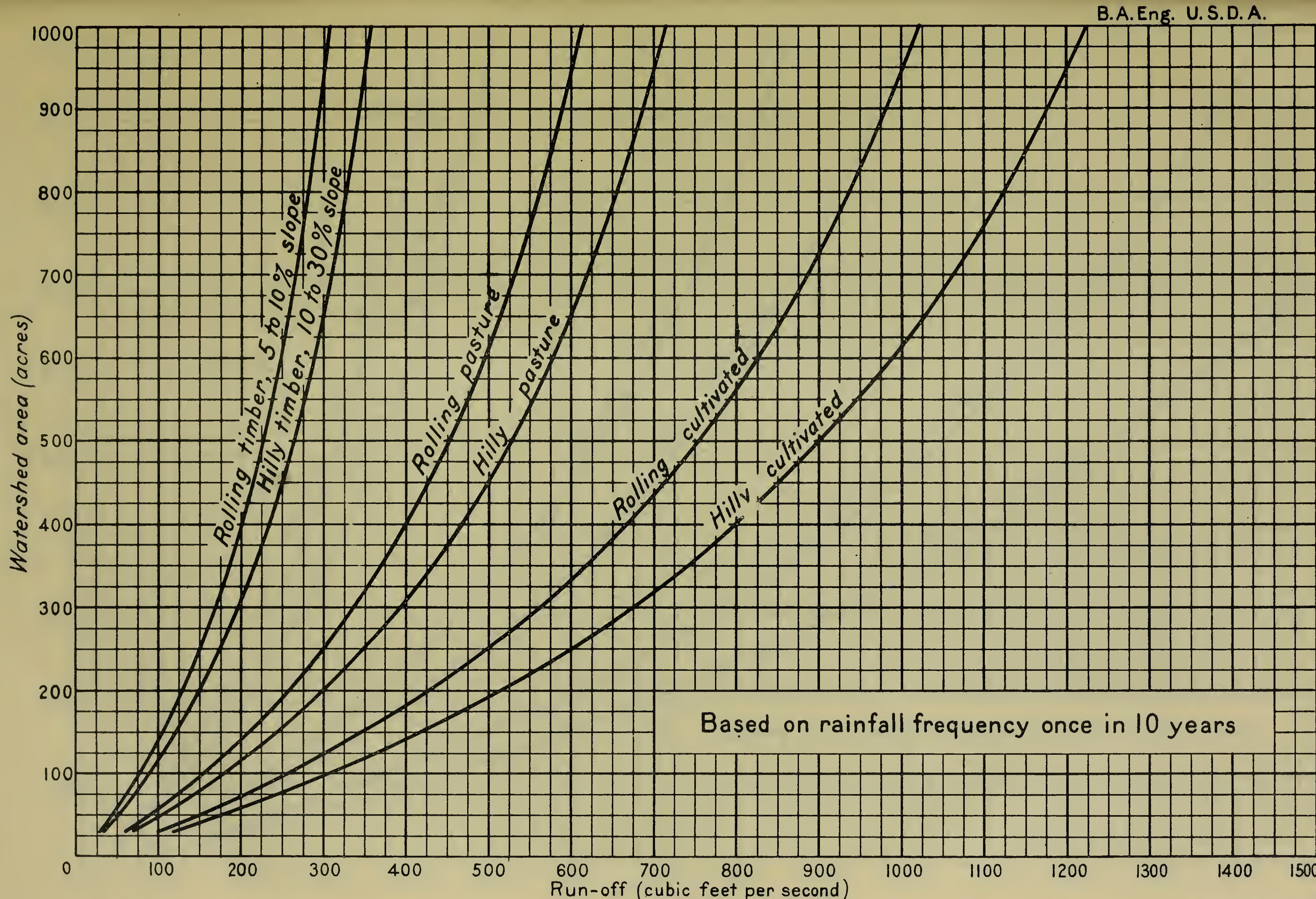


Fig. 15.- Rates of run-off from timber, pasture, and cultivated watersheds for area group no. 3 shown in Fig. 17

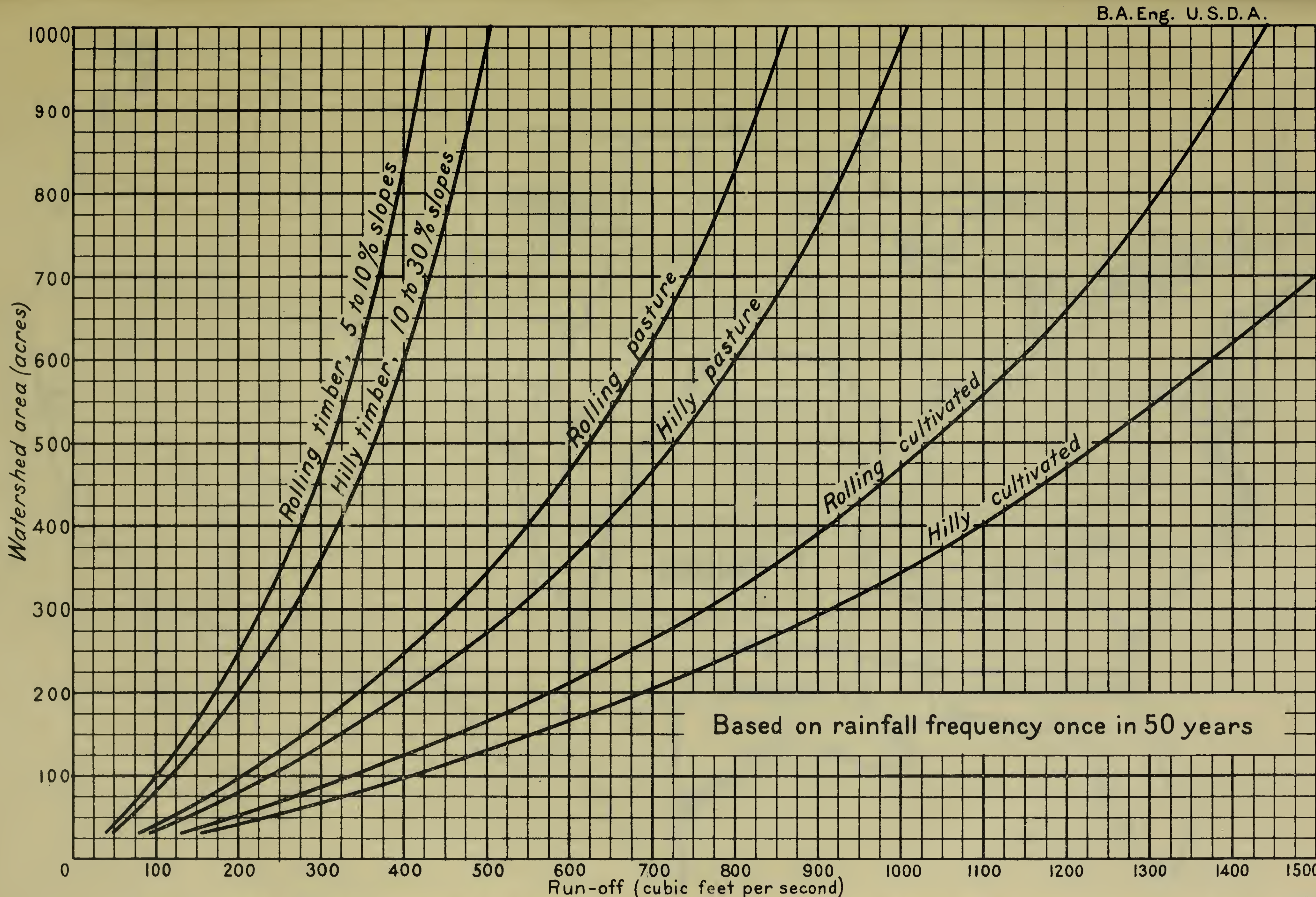


Fig. 16.- Rates of run-off from timber, pasture, and cultivated watersheds for area group no.3 shown in Fig. 17

Fig. 17.- Boundaries of areas of similar rainfall intensities for short periods. *(From Meyer's Hydrology)*